THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 33 AUGUST, 1927 No. 4

A PLEOMORPHIC AND GAS-FORMING BIPOLAR BACILLUS ISOLATED FROM THE LYMPH GLANDS OF SLAUGHTERED CATTLE

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TWO PLATES

INTRODUCTION

The serum laboratory of the Bureau of Science has been receiving from time to time specimens of lymph glands taken from domestic hogs and carabaos. As the specimens were received already fixed in preservatives no bacteriological examination could be made to decide the etiology of the disease from which the animals had suffered. In general, the histopathologic picture was that of hæmorrhagic lymphadenitis. Fresh specimens were therefore requested, and an attempt was made to isolate the causative organism. A bipolar bacillus was isolated from the first specimen. In order to secure more material for study request was made for specimens of supposedly diseased lymph glands from recently slaughtered cattle. So far as could be ascertained all gave the same bacteriological findings. All of the specimens were submitted by the Meisic Station of the Philippine Health Service, Manila. The first sample was submitted October 27, the second November 4, and the third November 5, 1925.

BACTERIOLOGIC STUDY

Method of isolation.—The superficial portion of the lymph gland was carefully dissected and exposed and was then sterilized with a hot spatula and opened with a sterile scalpel. A small

part of the internal portion was scraped and transferred to a sterile mortar and ground. An emulsion was prepared from the ground material in sterile salt solution and 2 cubic centimeters of the emulsion were injected subcutaneously into each of several rabbits. The usual result was that the animal died within eighteen hours after injection, and sometimes earlier. Cultures were obtained from the heart blood, liver, spleen, pleural and peritoneal exudate, and the site of inoculation. The chocolate blood agar was found very serviceable, as growth was remarkably abundant after eighteen hours' incubation. Smears were prepared from the lymph glands directly, but only two of three samples exhibited a few typical bipolar bacilli in direct smears. However, the bacilli were recovered by culture from all animals inoculated with the lymph glands. The strains thus obtained were labeled as strain G–1, strain G–2, and strain G–3, respectively.

Lymph glands of cattle.—When fresh the glands were enlarged and red, but a few were grayish.

The histological sections measured from 5 by 7 to 6 by 9 millimeters.

The microscopic lesions showed thickening of the capsule, and distention and rupture of the blood sinuses, especially noted at the cortical portion around the lymph nodes and in the medullar portion. There was also marked œdema (see Plate 2, figs. 8 and 12).

Morphology.—The isolated bacillus is readily stained with the ordinary aniline dyes. It is an aërobe and facultative anaërobe. It is gram-negative and bipolar with rounded ends. This is well seen in the smears prepared either from the internal organs or from the heart blood of the animals (Plate 1, fig. 1). It shows Brownian movement, similar to that of recently isolated *Bacillus dysenteriæ.* When stained, it measures from 1 to 1.64 microns in length and from 0.54 to 0.65 micron in width. (Ocular micrometer No. 3; drawtube = 0; objective $\frac{1}{12}$; Carl Zeiss.) The bipolar characteristic is lost in many of the bacteria when grown in the culture medium. It grows at room temperature (28.5° C.) on chocolate blood agar.

Broth culture.—The broth becomes uniformly cloudy after twenty-four hours, but a pellicle is formed as early as the third day. This pellicle starts to form from the walls of the test tube and is adherent, becoming ring-shaped, and later may extend to the center of the broth medium's surface. It gradually falls to the bottom and a viscid sediment is thus produced. The

smears prepared from this sediment may show chain formations of varying length, especially noted in some of the bouillon tubes directly inoculated with a few drops of heart blood of the infected animals (Plate 1, fig. 6). The middle portion of the bouillon remains partially clear for a few days.

Ordinary acid agar.—On slant the growth is similar to that of streptococcus; the colonies are discrete, grayish, and raised. The three-day-old colonies, especially those that exhibit pleomorphic forms, may have an undulated margin with raised center (low power). If subculture is carried repeatedly on acid agar, different morphologic forms may be observed, such as unbranched, long myceliumlike forms, elongated and rather large bacilli, occasional short chains, and thin filaments (see Plate 1, figs. 3, 4, and 5). These forms are particularly conspicuous in cultures growing on slanted agar to which about 1.5 cubic centimeters of saline solution had been added previous to sterilization.

The shake culture in stab agar shows an abundant growth 3 millimeters below the surface.

Chocolate blood agar.—The growth on chocolate blood agar is abundant and the morphology of the bacilli more uniform than on any other medium. The bacilli are short tapering at the ends; some are diplococcuslike forms resembling pneumococcus, others bipolar, and very few solid rods. The colonies are grayish, moist, and raised, with a round margin. An isolated colony on chocolate medium may have a diameter of 1 to 2 millimeters in twenty-four hours. The average size of the bacillus is from 0.82 to 1 micron, as shown in Plate 1, fig. 2. This photomicrograph was taken from a subculture which was made from the acid-agar culture showing long filaments, as shown in Plate 1, fig. 3.

Potato medium.—There is invisible growth on potato medium. Smear from it shows even forms of short bacilli and the bipolar characteristic is exhibited. The organism dies off in culture within a few days.

Dunham's peptone solution.—The nitroso-indol can be detected in Dunham's peptone solution as early as eighteen hours, and it is very strongly pronounced on the third day. This reaction was controlled by known strains of *Bacillus paratyphosus* B and *B. coli.*

Nitrate broth.—There is reduction with nitrate broth.

Gelatine.—Six tubes were inoculated with gelatine, two of each strain. None of them was liquefied.

Eosin-methylene-blue lactose agar.—No growth was observed on seventy-two hours' incubation, using eosin-methylene-blue lactose agar.

Litmus milk.—After a few days the litmus milk culture produces slight acidity. The addition of acetic acid causes precipitation of the caesin. Care must be taken, as the viscid growth at the bottom of the broth culture can be mistaken for reduction of the indicator. Such mistake can be avoided by lifting the viscid growth slowly with a needle; then the reaction can be seen to be very slightly acid throughout the culture medium.

Biochemical reactions.—The gas formation was determined by the use of the Smith fermentation tube, containing sugar-free bouillon with 1 per cent of the particular carbohydrate. The culture medium was adjusted to +0.3 per cent against phenolphthalein. The gas collected in the closed arm was measured in centimeters and is so expressed by the figures in Table 1. The closed arm is 1.2 by 10 centimeters. It was noted that the gas was not produced regularly from the beginning in the sugars that were attacked, excepting sorbite, in which case the three tubes inoculated with the three respective strains exhibited gas within twenty-four hours. Still greater irregularity in gas production was noticed when solid media were used, especially in the case of monosaccharides.

The outcome of the acid titration was strikingly in accord with the reactions in the sugars that were affected, as will be seen on comparing Tables 1 and 2, which are self-explanatory. The titration was made with 5 cubic centimeters of the culture fluid against 0.2 *N* sodium hydroxide.

Table 2 shows that the two hexoses glucose and galactose and their respective alcohols sorbite and dulcitol are easily utilized by this organism as food. Maltose is also attacked from the beginning of the growth. The irregularity in reactions with some sugars may be due to chemical changes, depending on the media used and on the duration of sterilization. For this reason comparative experiments were carried out, and these are tabulated in Table 2.

Acidity and gas production were recorded after forty-eight hours on account of the irregularity in the production of gas before that time; but it was noticed that glucose, galactose, maltose, sorbite, and dulcite were uniformly utilized forty-eight hours after inoculation in either of the two kinds of media used (see Table 2).

TABLE 1.—*Showing amount of gas produced in the closed arm of the Smith fermentation tube. The closed arm measures 10 centimeters. Sugar-free broth. (+0.3) phenolphthalein, March 2, 1926.*

[Figures, amount of gas in centimeters; B, bubble (about 2 millimeters width); 0, no gas.]

Carbohydrate 1 per cent.	Make.	March 4, 1926.			March 7, 1926.			March 9, 1926.			March 11, 1926.			March 13, 1926.			March 25, 1926.			Titration (phenolphthalein) sodium hydroxide 0.2 *N*.	
		G-1	G-2	G-3	G-1	G-2	G-3	G-1	G-2	G-3	G-1	G-2	G-3	G-1	G-2	G-3	G-1	G-2	G-3	Control.	Average.
Glucose	Merck	B	0	B	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1	2.6	4.6
Galactose	Pfanstiehl	0	0	0	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	1	1	1	1	1	2.3	3.7
Levulose	do	0	0	0	0	0	0	0	0	0	B	0	0	B	0	0	B	0	0	2.00	3.8
Arabinose	do	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.2	2.2
Xylose	Eimer and Amend	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.6	2.9
Rhamnose	Pfanstiehl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5	1.5
Maltose	do	0	0	0.5	0	0	0.5	0	B	0.5	0	B	0.5	0	B	1	0.5	0.5	1	([a])	3.05
Lactose	do	0	0	0	0	0	B	0	0	1	0	1	1	1	1	1	1	1	1	1.6	2.4
Sucrose	Merck	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6	1.6
Amygdalin	Eimer and Amend	0	0	0	B	0	B	B	0	B	B	0	B	B	B	B	B	B	B	1.3	1.3
Salicin	Kahlbaum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	1.1
Raffinose	The Will Co. B. & L.	0	0	0	0	B	0	0	B	0	0	B	0	0	B	0	0	B	0	1.5	1.4
Dextrin	Kahlbaum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6	1.2
Sorbite	Merck	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	3	3	3	3	3	3	3	3	3	1.8	4.15
Dulcitol	Pfanstiehl	0	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1.6	3.85
Mannitol	do	0	0	0	0	0	0	0	0	0	0	0	0	B	0	0	B	0	0	1.5	1.5
Glycerine	U. S. P.	0	0	0	0	0	0	0	0	B	0	0	B	0	0	B	0	0	B	1.6	2.1
Adonitol	Pfanstiehl	0	0	0	0	0	B	B	B	B	B	B	B	B	B	B	B	B	B	1.8	1.8

[a] Broken.

TABLE 2.—*Showing comparative reactions of the three strains with different media.*

[++, acid and gas; +, acid alone; B+, bubble and acid; S+, slightly acid; +?, doubtfully acid; —, negative or no change; — — not used.]

Carbohydrate 1 per cent.	Sugar-free broth (+0.3) phenolphthalein litmus blue. Arnold three times. Inoculated March 16, 1926. Smith fermentation tube.									Peptone-salt-water (+0.5) phenolphthalein litmus blue. Arnold twice. Inoculated April 27, 1926. Durham fermentation tube.								
	March 18, 1926.			March 25, 1926.			April 8, 1926.			April 29, 1926.			May 3, 1926.			May 9, 1926.		
	G–1	G–2	G–3	G–1	G–2	G–3	G–1	G–2	G–3	G–1	G–2	G–3	G–1	G–2	G–3	G–1	G–2	G–3
Glucose	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
Galactose	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
Levulose	++	++	++	++	++	++	++	++	++	+	B+	B+	++	++	++	++	++	++
Arabinose	+	+	+	++	++	++	++	++	++	—	—	—	—	—	—	—	—	—
Xylose	—	—	—	+	++	+	++	++	++	+?	+?	+?	+?	B+	B+	++	++	++
Rhamnose	+?	+	+	+?	B+	++	+?	++	++	—	—	—	—	—	—	—	—	—
Maltose	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
Lactose	+	+	+	++	++	++	++	++	++	—	—	—	—	—	—	—	—	—
Sucrose	+	+	+	B+	++	++	B+	++	++	—	—	B+	—	—	++	—	—	++
Amygdalin	—	—	—	B+	B+	B+	B+	B+	B+	—	—	—	—	—	—	—	—	—
Salicin	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Raffinose	—	—	—	+?	B+	B+	+?	B+	B+	—	—	—	—	—	—	—	—	—
Dextrin	—	—	—	+?	++	++	+	++	++	—	—	—	—	—	—	—	—	—
Sorbitol	++	++	++	++	++	++	++	++	++	++	+	++	++	+	++	++	+	++
Dulcitol	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
Mannitol	—	—	—	+	++	++	+	++	++	+?	—	—	+?	—	—	B+	—	—
Glycerol	+?	+?	+?	+?	B+	B+	B+	B+	B+	—	—	—	—	—	—	—	—	—
Adonitol	+?	+?	+?	+?	+?	+?	+?	+?	+?	—	—	—	—	—	—	—	—	—
Inositol (Pfanstiehl)	— —	— —	— —	— —	— —	— —	— —	— —	— —	—	—	—	—	—	—	—	—	—

TABLE 2.—*Showing comparative reactions of the three strains with different media*—Continued.

Carbohydrate 1 per cent.	Peptone-salt-water Andrade indicator, autoclaved 15 pounds, ten minutes. Inoculated March 24, 1926. Durham fermentation tube.								
	March 27, 1926.			March 31, 1926.			April 10, 1926.		
	G–1	G–2	G–3	G–1	G–2	G–3	G–1	G–2	G–3
Glucose	++	++	++	++	++	++	++	++	++
Galactose	++	++	++	++	++	++	++	++	++
Levulose	—	—	—	—	—	—	++	++	++
Arabinose	+?	+?	+?	S+	B+	S+	S+	B+	S+
Xylose	—	—	—	—	—	—	—	—	—
Rhamnose	—	—	—	—	—	—	—	—	—
Maltose	++	++	++	++	++	++	++	++	++
Lactose	—	—	—	—	—	—	—	—	—
Sucrose	—	—	—	—	—	—	—	—	—
Amygdalin	—	—	—	—	—	—	—	—	—
Salicin	—	—	—	—	—	—	—	—	—
Raffinose	—	—	—	—	—	—	—	—	—
Dextrin	—	—	—	—	—	—	—	—	—
Sorbitol	++	++	++	++	++	++	++	++	++
Dulcitol	++	++	++	++	++	++	++	++	++
Mannitol	—	—	—	—	—	—	—	—	—
Glycerol	—	—	—	—	—	—	+	—	+
Adonitol	—	—	—	—	—	—	—	—	—
Inositol (Pfanstiehl)	—	—	—	—	—	—	—	—	—

The peptone-salt-water (Dunham's solution) containing 1 per cent carbohydrate and 1 per cent Andrade indicator was adjusted against 0.1 N sodium hydroxide. The final adjustment was made in such a way that it was pink when heated, but it became colorless when cool.

Heat resistance.—Twelve twenty-four-hour broth cultures, four for each strain, were exposed to different degrees of heat in the water bath. Every fifteen minutes one tube from each set was taken out and immediately cooled off with tap water. By means of a 4-millimeter loop, subcultures were made from all tubes and reading was made after forty-eight hours' incubation. The results are shown in Table 3.

TABLE 3.—*Showing resistance of the three strains to heat.*

Culture.	Temperature.											
	50° C.				53° C.				56° C.			
	15 min.	30 min.	45 min.	60 min.	15 min.	30 min.	45 min.	60 min.	15 min.	30 min.	45 min.	60 min.
G–1......	+	+	—	—	—	—	—	—	—	—	—	—
G–2......	+	—	—	—	—	—	—	—	—	—	—	—
G–3......	+	+	—	—	—	—	—	—	—	—	—	—

EXPERIMENTAL STUDY

The three strains were found to be pathogenic for rabbits, guinea pigs, mice, and chickens. Young animals were more susceptible to inoculation than were old ones. All, with the exception of the chickens, which will be described below, died in the acute stage of their illness.

RABBITS

Subcutaneous injection.—One cubic centimeter of eighteen-hour broth culture proved fatal to rabbits. In general, the animals died or were found dead the morning following inoculation. At autopsy there was acute œdematous inflammation with little effusion of blood or ecchymoses of varying degree at the site of inoculation or in the axillary region. This was particularly pronounced when the strain was passed through experimental animals several times. Nothing noteworthy was found in the internal organs, with the exception of a small amount of pleural and peritoneal exudate which was at times tinged with blood.

In one of the rabbits that received subcutaneous injection of cattle lymph-gland tissue, a swollen and red lymph gland was

found in the axillary region near the hæmorrhage. The findings in the histological section of the tissue were as follows: The lymph gland was surrounded with clot and showed an acute and extensive extravasation of blood elements in the medullary and in the cortical region below the capsule and around the germinal center which is practically free of blood elements. The blood sinuses were engorged and the blood elements were infiltrating the neighboring tissue. The cellular elements were found loose in structures of the tissue.

Intravenous and intraperitoneal injection.—One cubic centimeter of twenty-four-hour broth culture was used. Either intravenous or intraperitoneal inoculation leads to the death of rabbits within five or eighteen hours. The rabbit that received intravenous injection became quiet, soon his ears flopped down, the muscles trembled, the respiration became accelerated and superficial, and the animal died in a sitting position.

GUINEA PIGS

Subcutaneous injection.—Five-tenths cubic centimeter of twenty-four-hour broth culture was used. The guinea pigs were found to be less susceptible than were the rabbits; but, as a general rule, if death occurred, it was at about the same period after inoculation as in the rabbits. Congestion of the suprarenal glands was not infrequently met with. One guinea pig, injected with strain G–2, died forty-eight hours after injection.

On one occasion a culture was isolated from the liver of an inoculated rabbit which died after intraperitoneal injection with strain G–1. Two guinea pigs inoculated with the culture isolated from the rabbit's liver did not die. Upon examining the guinea pigs a large, cheesy tumefaction was found under the skin in both, at the site of inoculation. However, a rabbit that was injected subcutaneously with the same culture as that used on the two guinea pigs was found dead the following morning, with the usual lesions and an extensive hæmorrhage at the site of inoculation.

The guinea pigs showing tumefaction were killed ten days after inoculation. Pure culture of the organism in question was obtained from the pus withdrawn. A guinea pig and a rabbit were injected with this culture; both died the following morning, and again the organism was recovered from the organs of these animals.

Toxin.—Ten cubic centimeters of the filtrate of one-week-old broth culture inoculated with strain G–1 killed a guinea pig

in forty-eight hours. The control animal injected with plain broth remained alive.

MICE

Subcutaneous injection.—One-fourth of 1 cubic centimeter of twenty-four-hour broth culture was inoculated. The mouse injected with strain G–1 was found dead the following morning. At autopsy there was no characteristic lesion except a little effusion of blood at the site of inoculation and signs of acute inflammation. The organism was isolated from the internal organs and from the peritoneal and pleural exudate.

CHICKENS

Subcutaneous injection.—One-sixth of a loopful of culture on chocolate blood agar was used for injection.

Two chickens, about 3 months old, were injected with strains G–2 and G–3, respectively. The chicken that received strain G–3 was very sick the following morning, the neck drawn to the body, and remained quiet in a corner but took food and water occasionally. The animal passed fluid fæces at this time with thin mucus and white specks. On the fourth day the feathers around the neck were roughened, the eyes were partially closed, and the eyelids were glued with a thick fibrinous exudate. After six days the animal began to walk about and it finally recovered a few days later. The other chicken, inoculated with strain G–2, showed similar symptoms but of lesser degree, and it recovered in three days. The animals were discarded and no further observation was made.

Intramuscular injection.—One-fifth of a slant culture on chocolate blood agar diluted in salt solution was employed. This method gave more uniform results. Three one-month-old chickens were injected in the pectoral region, each with one of the three strains. The chicken injected with strain G–1 died in six days; the one with strain G–2 died in eight days; and the other, which received strain G–3, died in five days.

In general, the animals became indifferent to food, the neck was drawn to the body, the feathers around it were roughened, the wings flopped down; later the animals lay down with legs outstretched and remained in this position until they suddenly died. The borders of the eyelids were partially covered with thick mucus. Difficulty of respiration was a common symptom in these animals. At autopsy there was no marked change in the internal organs, except a slight congestion of the lungs. The liver was somewhat friable and pale.

One culture obtained from the secretion of the eye in one of the chickens that had been injected with strain G–2 proved fatal to a guinea pig on subcutaneous injection.

The macroscopical changes at the site of intramuscular injection varied in the three animals. In one of the chickens the muscle tissue where inoculum was made had a whitish color, as though the bird had been submerged in boiling water for a few seconds (boiled meat). The other two exhibited lesions as follows: Below the thin superficial layer of muscle tissue, when opened, there appeared a thick parchmentlike substance, which was rather easily detachable from the neighboring tissue and was granular and yellowish. Around this there was a cavity formation, due to the shrinkage of the central tissue and the surrounding necrotic area. These showed different degrees of necrosis (see Plate 2, fig. 9). The microscopical pictures showed the following: The one with the appearance of boiled meat showed fragmentation of the muscle fibers; the fibrils were swollen and in some parts the striations were lacking; cellular infiltration, composed of mononuclear cells, was found between the muscle fibers; the sections from the granular parchmentlike tissue showed marked disintegration of the various elements of the muscular tissue. Starting from the surface the following changes were observed: Homogeneous disintegration of the tissue followed by marked infiltration of mononuclear cells forming, above it, columns which were located between the muscle fibers that had undergone various stages of necrosis (see Plate 2, fig. 11).

Feeding inoculation.—One chicken was fed with one-tenth of a slant on chocolate blood agar of strain G–1. The animal was apparently normal up to the thirteenth day. On the fifteenth day it appeared to be very sick, showing symptoms as described above in inoculated chickens. It commenced to close the right eye. Upon examination, the cornea was found blurred and covered with a thick mucoid secretion. The symptoms became aggravated, the animal refused to eat, and on the twentieth day it was found dead. At autopsy the chicken was found extremely emaciated; the pectoral muscle was pale and atrophied; the liver was dark with whitish spots (fatty necrosis ?) (see Plate 2, fig. 7); the heart was pale and mottled at the ventricles; the lungs were collapsed, and gray with a greenish tinge.

Hypostatic congestion was not infrequent in animals that were found dead. The organism in question was recovered in pure

culture from all of the experimental animals and tested for its pathogenicity.

DISCUSSION

Woolley and Jobling(8) reported hæmorrhagic septicæmia in Philippine cattle. Shortly before they had finished their investigation, they received the report of the Government bacteriologist at Hongkong on the disease which was prevalent there and was known as cattle plague. A summary of the report on the characteristics of the organism is given in the footnote of Woolley and Jobling's paper, which is here partly quoted, as follows:

> This germ grew readily on the "ordinary culture media." It was a bacillus that stained more deeply at the poles, and which did not stain by Gram's method and which was nonmotile. Its appearance on culture media was similar to that of *B. coli.* All inoculated animlas [sic] died after twenty-four to forty-eight hours with symptoms of septicæmia. From his facts Hunter concluded that he is dealing with a form of hemorrhagic septicæmia.

However, Woolley and Jobling reported different types of organism isolated from their reported cases.

Washburn(7) reported a number of outbreaks of a disease resembling hæmorrhagic septicæmia in all its manifestations and anatomical changes. His comment is as follows:

> In a number of outbreaks of a disease resembling hemorrhagic septicaemia in all its manifestations and anatomical changes an organism which differs in cultural characteristics from the true *B. bipolaris septicus* has been recovered. This organism proves to be virulent for experimental animals (rabbits and guinea pigs), producing in them changes suggestive of hemorrhagic septicæmia. In preparations from affected tissue or body fluids the organism stains bipolar, and usually occurs singly or occasionally in pairs. It differs from the true *B. bipolaris septicus* in that it appears slightly larger, possesses sluggish motility, and produces gas in sugar media. In its cultural characteristics it corresponds in most instances to bacteria of the colon group, although some of the characteristics possessed by the paratyphoid B-group have been noted.

Cahill(3) noted on numerous occasions the absence of *Pasteurella boviseptica* and isolated *Bact. paratyphoid* from cattle and swine that were suffering from what clinically appeared to be typical hæmorrhagic septicæmia. He claims that his findings are in accord with those of Washburn. McGowan and Chung Yik Wang(5) described a strain of *B. bovisepticus* obtained from the heart blood of a case with symptoms and post-mortem appearances typical of hæmorrhagic septicæmia. In many respects it resembles members of the *B. coli* group. It is interesting to note their experiment on the mutation of *B. avisepticus*

which became motile and gas producing after a series of intraperitoneal passages in guinea pigs. The original was nonmotile and did not produce gas in carbohydrate media. With regard to this transformation, they believe that the bipolar and gas-forming bacilli were modified hæmorrhagic septicæmia organisms. Their belief was strengthened by the fact that these bacilli were obtained in pure culture. This problem requires thorough study, and the outcome of further investigations may throw light on the true nature of the gas-forming organisms hitherto described as belonging to the hæmorrhagic septicæmia group, or *Pasteurella*. The definition given by Buchanan (2) of *Pasteurella* seems to be adequate for the time being, as no other could cover both gas and nongas-forming organisms. He defines the organism as—

> Short rods, single or rarely in chains, usually showing distinct polar staining. Non-motile, Gram-negative. Without spores. Aerobic and facultative, *usually* not producing gas, powers of fermenting slight, often pathogenic, not acid-fast, not liquifying gelatine.

Claims of the wide distribution of bipolar ovoid organisms in nature have been upheld by various observers as, being saprophytic, they may become pathogenic after so many passages through susceptible animals. In fact, Forgenson (4) isolated thirty-seven strains of *Pasteurella boviseptica* from the nasal chambers of two hundred fifty normal cows. Only nongas-forming bacteria were identified; those that gave gas were discarded. Attempts to reproduce the disease by feeding have failed in the hands of some experimenters and the result obtained by us in a single chicken which was fed with strain G–1 is far from being conclusive. The chicken presented symptoms similar to those of *B. pollorum*. However, the biological properties are entirely different.

The chain formation seems to be common among members of the hæmorrhagic septicæmia group. Brimhall (1) has observed that *B. bovisepticus* was found in chains of three to twelve individuals. These forms are also not uncommon in *B. pestis*, as shown by Rowland. (6) The streptococcuslike formation seems to be favored by the addition to the bouillon of a little serum or blood; it was observed by Rowland in the broth culture of *B. pestis* to which horse serum had been added in the proportion of 10 per cent. I was able to find long-chain formations in broth culture that was directly inoculated with blood taken aseptically from experimental animals (Plate 1, fig. 6). They were Gram-negative. McGowan and Chung Yik Wang (5) described a long

mycelial growth of *B. ovisepticus* on salt-agar medium the photomicrograph of which is similar in many respects to that found by Rowland(6) in *B. pestis* as well as the one described in this paper (Plate 1, fig. 3). Investigators remarked that the pleomorphism may link closely the members of hæmorrhagic septicæmia with *B. pestis.*

From the standpoint of morphology, pathogenicity, and some cultural characteristics, the three strains isolated by me which are serologically alike (1×200) behave like those of the hæmorrhagic septicæmia group.

SUMMARY AND CONCLUSIONS

Three strains of a bacillus were isolated from lymph glands of slaughtered cattle. They are bipolar, aërobic and facultative, Gram-negative, nonmotile, nonliquefying gelatine, grow feebly in ordinary media, and grow well 3 millimeters below the surface of stab agar (shake method). Generally they attack glucose, galactose, maltose, sorbite, and dulcite with the production of gas. They are pleomorphic and do not grow on eosin-methylene-blue agar, in which medium *B. coli* and the typhoid-dysentery group grow.

All three of the strains were found to be pathogenic for rabbits, guinea pigs, mice, and chickens. Death occurs in from five to forty-eight hours following inoculation, although rabbits die in a much shorter period, as they are more susceptible than are guinea pigs.

In chickens the organism in question produced symptoms similar to those known in chickens infected with *B. pollorum.*

The only previous history of the cattle from which the lymph glands were taken was that one of the animals came from Mindoro Province.

Whether or not this organism is the same as that described by the Government bacteriologist at Hongkong, as cited by Woolley and Jobling, is difficult to say. The finding of such an organism calls for a general survey in order that its connection with native and imported cattle may be studied.

The isolation of gas-forming and bipolar organisms in typical cases of hæmorrhagic septicæmia is beyond doubt. However, no definite cultural characteristics were given. The morphology, some biological characteristics, and the pathogenicity of the organisms isolated by me lead to the conclusion that they belong to the hæmorrhagic septicæmia group, or *Pasteurella.*

ACKNOWLEDGMENT

I wish to express my sincere appreciation to Dr. Otto Schöbl, chief of the division, for reading the manuscript of this paper and making some corrections, for which I am indebted to him.

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ILLUSTRATIONS

Plate 1

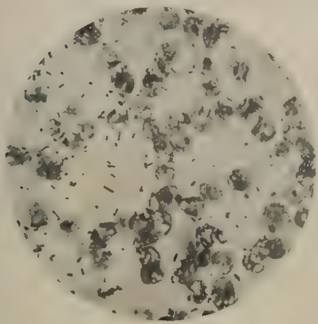
Fig. 1. Smear from heart blood of experimental rabbit, stained with Wright's. Note the characteristic bipolar organisms. × 520.

2. Smear from chocolate medium, stained with carbol-fuchsin 1 × 10. This is a subculture of that showing long filaments (fig. 3). Note the loss of bipolar characteristics on medium. × 520.
3. Smear showing unbranched mycelia (carbol-fuchsin 1 × 10). From ordinary agar to which saline solution was added before sterilization. × 520.
4. Smear from ordinary agar without saline solution, showing changes of morphology. Carbol-fuchsin 1 × 10. × 520.
5. Smear from ordinary agar with saline solution, showing variety of forms and segmentation of filament. Carbol-fuchsin 1 × 10. × 520.
6. Smear showing streptococcuslike formations. This was prepared from the viscid growth in a broth culture directly inoculated with infected rabbit blood. Gram-negative. × 520.

Plate 2

Fig. 7. Chicken's liver, showing whitish spots (fatty necrosis?). The liver is from the chicken that was inoculated by mouth. Natural size.

8. Section of lymph gland of a cow showing extension of hæmorrhage below the capsule, and œdema.
9. Half of chicken's breast showing the granular parchmentlike tissue and the cavity formation around it. Natural size.
10. Other half of the chicken breast (see fig. 9), which is normal.
11. Section of parchmentlike tissue (fig. 9), showing different degrees of necrosis of the muscle fibers and marked mononuclear infiltration. × 220.
12. Lymph gland of a cow showing extension of hæmorrhage into the blood sinuses. × 220.



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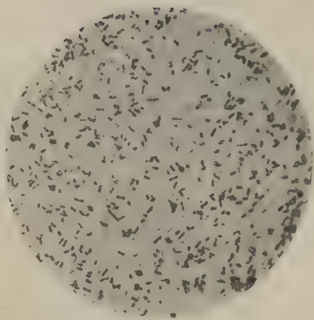

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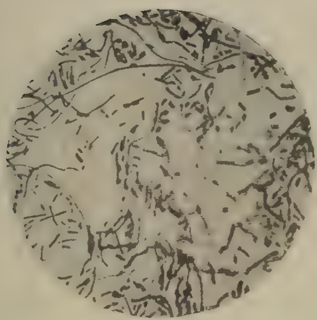

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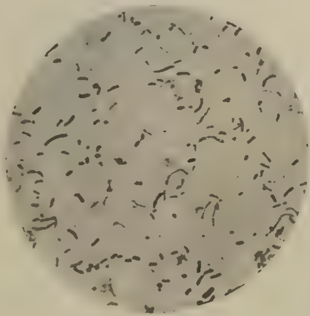

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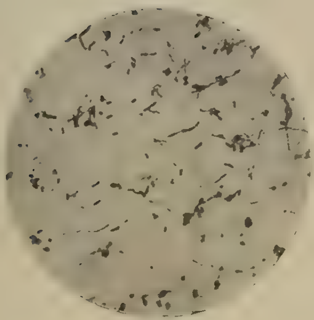

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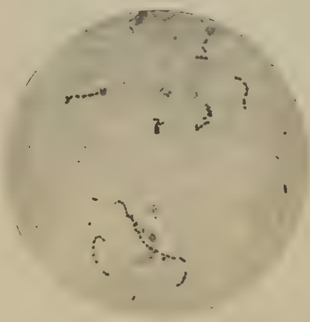

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PLATE 1.

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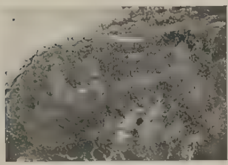

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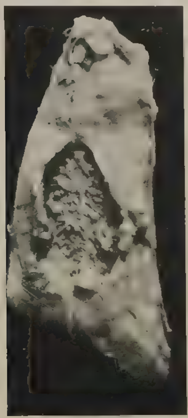

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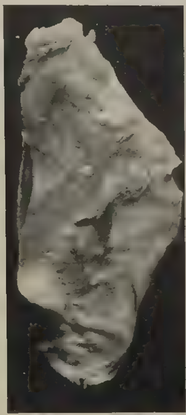

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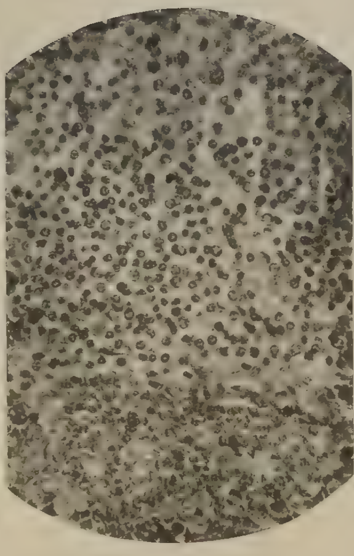

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PLATE 2.

SALTS OF ALPHA LINOLIC TETRABROMIDE (CADMIUM, COBALT, COPPER, MAGNESIUM, AND MANGANESE) FROM PHILIPPINE LUMBANG OIL

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Philippine lumbang oil is obtained from the seeds of *Aleurites moluccana*.[1] It consists almost entirely of glycerides of the unsaturated acids, linolenic, linolic, and oleic.[2] It is a drying oil and is used in making paints, varnishes, and similar products.[3]

A recent investigation [4] indicated that various linolic glycerides, corresponding to different linolic acids, can be obtained from lumbang oil. Linolenic glyceride and the linolic glycerides are the principal substances that absorb oxygen from the air and cause the oil to dry.[5] Alpha linolic glyceride and the corresponding alpha acid are therefore substances of considerable importance. When exposed to air these substances oxidize readily, but they may be separated from an oil in the form of a stable tetrabromide.[6] Crystallized alpha linolic tetrabromide is an important substance in the chemistry of drying oils, since it is a stable form of alpha linolic compounds.

$$CH_3(CH_2)_4\overset{Br}{\overset{|}{C}}H\text{-}\overset{Br}{\overset{|}{C}}HCH_2\overset{Br}{\overset{|}{C}}H\text{-}\overset{Br}{\overset{|}{C}}H(CH_2)_7COOH$$

alpha linolic tetrabromide

[1] West, A. P., and W. H. Brown, Bull. P. I. Bur. Forestry **20** (1920) 121.

[2] West, A. P., and Z. Montes, Philip. Journ. Sci. **18** (1921) 619.

[3] West, A. P., and F. L. Smith, Bull. P. I. Bur. Forestry **24** (1923).

[4] Santiago, S., and A. P. West, Philip. Journ. Sci. **33** (1927) 265.

[5] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes **2** (1922) 42.

[6] Lewkowitsch, J., op. cit. **1** (1921) 202.

According to the literature very few derivatives [7] of the alpha tetrabromide have been prepared. In view of this fact, it seemed desirable to make a few salts of this substance and determine their solubility in different organic solvents. The data thus obtained may be useful in devising new methods for separating mixtures of the various linolic tetrabromides.

EXPERIMENTAL PROCEDURE

Preparation of alpha linolic tetrabromide.—Philippine lumbang oil was used as the material for preparing a supply of alpha linolic tetrabromide. The lumbang oil was pressed from seeds of good quality and filtered, first through glass wool and then through filter paper.

The alpha linolic tetrabromide was prepared from lumbang oil in accordance with the procedure adopted by Santiago and West [8] in a recent investigation of lumbang compounds. The lumbang oil was saponified with aldehyde-free alcoholic potassium hydroxide.[9] The mixed potassium soaps thus obtained were converted into the mixed acids. The mixed acids were brominated in ether solution according to the procedure used by Imperial and West [10] in preparing linolenic hexabromide. The ether solution of mixed acids was stirred mechanically by means of a hot-air motor and brominated at —10° C. The insoluble linolenic hexabromide was removed by filtering.

The ethereal filtrate from the hexabromide was treated with sodium thiosulphate solution to remove the bromine, dehydrated with sodium sulphate, and distilled to eliminate the ether. The residue was treated with cold petroleum ether which precipitated a mixture of linolic tetrabromides. The crude solid tetrabromides were separated from the oily (gamma) tetrabromide and oily oleic dibromide by filtering. The crude crystalline tetrabromides were washed with petroleum ether, after which they were crystallized from ethyl alcohol. Two crops of impure alpha linolic tetrabromide (melting point, 110 to 113° C.) were obtained. The crude alpha tetrabromide was washed again with petroleum ether and crystallized once from gasoline and several times from ethyl alcohol. After this further purification the melting point was 112.3 to 114.3° C.

[7] Lewkowitsch, J., op. cit. 1 (1921) 204; Oreta, A. T., and A. P. West, Philip. Journ. Sci. 33 (1927) 169.

[8] Philip. Journ. Sci. 33 (1927) 265.

[9] Dunlap, F. L., Journ. Am. Chem. Soc. 28 (1906) 397.

[10] Philip. Journ. Sci. 31 (1926) 441.

Salts of alpha linolic tetrabromide were prepared by first converting the acid into the potassium salt. An alcoholic solution of the potassium salt was then treated with a solution of an inorganic salt such as cobalt chloride. The precipitated salt thus obtained was purified, and the melting point and the solubility in various solvents were determined.

Potassium salt of alpha linolic acid tetrabromide.—Ten grams of alpha linolic tetrabromide were dissolved in 200 cubic centimeters of boiling ethyl alcohol. To this clear alcoholic solution there was added from a burette an excess of the half-normal alcoholic potassium hydroxide solution prepared with aldehyde-free alcohol. The mixture was heated (reflux) on the water bath for about five hours. On cooling the potassium salt separated out and was removed by filtering. The potassium salt was crystallized several times from ethyl alcohol until the filtrate was no longer yellow. The salt was then recrystallized once from methyl alcohol, filtered by suction, and transferred to a watch glass. The salt was then dried in a vacuum desiccator for several days.

Cadmium salt of alpha linolic tetrabromide.—Five grams of the potassium salt of alpha linolic tetrabromide were dissolved in 150 cubic centimeters of boiling methyl alcohol. The solution was filtered immediately into a half-liter round flask and placed on a water bath under a reflux condenser. A methyl alcohol solution of cadmium nitrate was prepared by dissolving 2 grams of cadmium nitrate [$Cd(NO_3)_2.4H_2O$] in 50 cubic centimeters of boiling methyl alcohol and filtering the solution immediately. This clear solution of cadmium nitrate, containing a slight excess of the calculated amount of cadmium nitrate, was then added gradually, through the top of the condenser, to the hot alcoholic solution of the potassium salt of the tetrabromide. A white bulky precipitate was formed immediately. The mixture was then heated (reflux) on the water bath for about an hour until the reaction was complete, as shown by the clear supernatant liquid. The supernatant alcoholic solution was then poured off from the precipitate. The precipitate was washed by decantation several times with hot methyl alcohol to extract the potassium nitrate, the excess cadmium nitrate, and all unchanged potassium salt of alpha linolic tetrabromide. The precipitate was then washed thoroughly with redistilled ether to eliminate the methyl alcohol, after which it was placed on filter paper and dried in a vacuum desiccator for several days.

A melting-point determination showed that the salt melts at from 135.7 to 137.8° C. without decomposition.

The salt was analyzed by treating a weighed quantity with concentrated sulphuric acid which converted the cadmium into cadmium sulphate. The residue was heated until it was white.

Analysis:

	Cadmium. Per cent.
Calculated for $C_{36}H_{62}Br_8O_4Cd$	8.58
Found	8.78

Cobalt salt of alpha linolic tetrabromide.—Five grams of the potassium salt of alpha linolic tetrabromide were dissolved in 150 cubic centimeters of hot ethyl alcohol. An alcoholic solution of cobalt chloride was prepared by dissolving 1.5 grams of cobalt chloride ($CoCl_2.6H_2O$) in 35 cubic centimeters of hot ethyl alcohol. This solution, containing a slight excess of the calculated amount of cobalt chloride, was then added to the alcoholic solution of the potassium salt previously prepared. A beautiful pink precipitate was formed immediately. The mixture was heated (reflux) for about one hour on a water bath. The supernatant liquid became clear, indicating that the reaction was complete. The supernatant liquid was poured off from the precipitate, which was washed several times by decantation with ethyl alcohol until entirely free of chlorides, as shown by the silver nitrate test of the washings. The precipitate was then poured on a filter, washed with ether, and dried in a vacuum desiccator.

A melting-point determination showed that at 155.9° C. the cobalt salt became slightly lighter in color, and at 156.5° C. it melted, forming opaque droplets which did not change, even when heated to about 190° C.

The formula of the salt was checked by converting a portion of it into metallic cobalt. A weighed amount of the cobalt salt was placed in a platinum crucible and ignited in the air. The cobalt was converted mostly into cobalto-cobaltic oxide,[11] black oxide of cobalt [Co_3O_4]. A portion of this oxide was transferred to a porcelain boat which was placed in a quartz combustion tube. The tube was gradually heated to redness and the oxide reduced to metallic cobalt with dry hydrogen gas previously purified.[12] It required about a half hour to complete the reduction. Once the weight is known of black oxide ob-

[11] Watts' Dictionary of Chemistry 2 (1912) 221.

[12] Ibid, 719.

tained and the portion used for the reduction, the percentage of cobalt is calculated readily.

Analysis:

	Cobalt. Per cent.
Calculated for $C_{36}H_{62}Br_8O_4Co$	4.70
Found	5.06

Copper salt of alpha linolic tetrabromide.—Five grams of the potassium salt of alpha linolic tetrabromide were dissolved in 150 cubic centimeters of hot methyl alcohol. A methyl alcohol solution of cupric chloride was prepared by dissolving 2 grams of cupric chloride ($CuCl_2.2H_2O$) in 80 cubic centimeters of hot methyl alcohol. This copper chloride solution, containing a slight excess of the calculated amount of cupric chloride, was then added gradually to the hot alcoholic solution of the potassium salt of the tetrabromide. A bluish green precipitate was formed immediately. After the mixture was heated for about one hour on a water bath the liquid above the precipitate became clear and was decanted from the precipitate. The precipitate was washed several times with hot methyl alcohol until the washings gave no chloride test with silver nitrate. The precipitate was then washed with ether, after which it was placed on filter paper, and then dried in a vacuum desiccator for several days.

A portion of the salt was crystallized from chloroform. A melting-point determination showed that at 142.4° C. the salt began to melt, and at 145.4° C. it was changed to an opaque greenish blue liquid.

The salt was analyzed by determining the copper as copper oxide. The procedure was as follows: About a half-gram portion of the salt was decomposed by treating it with an alcoholic solution of hydrochloric acid prepared by dissolving 1 cubic centimeter of concentrated hydrochloric acid in 20 cubic centimeters of hot ethyl alcohol. The cupric chloride and alpha linolic tetrabromide thus obtained as decomposition products are very soluble in hot ethyl alcohol. A slight excess of alcoholic potassium hydroxide solution was then added. Black copper hydroxide was precipitated and the blue color of the solution disappeared. To be sure that an excess of potassium hydroxide was present, about 4 cubic centimeters more of the alkali were added. The mixture was then heated on a water bath for about forty minutes to complete the precipitation. The copper hydroxide was then filtered through a Gooch crucible, ignited, and weighed as copper oxide. In carrying out this analysis a small portion of the precipitated copper hydroxide adhered

tenaciously to the side of the vessel in which the hydroxide was precipitated and was not easily removed. This residue was dissolved in concentrated nitric acid, and the solution transferred to a crucible and evaporated to dryness. The copper nitrate thus obtained was ignited, and weighed as copper oxide. This weight of copper oxide was added to the weight of the copper oxide previously obtained.

Analysis:

	Copper. Per cent.
Calculated for $C_{36}H_{62}Br_8O_4Cu$	5.04
Found	4.88

Magnesium salt of alpha linolic tetrabromide.—Five grams of the potassium salt of alpha linolic tetrabromide were dissolved in hot ethyl alcohol. The clear solution was treated with a hot alcoholic solution of magnesium chloride containing a slight excess of the calculated amount of magnesium chloride ($MgCl_2.6H_2O$). A white precipitate was formed immediately. After the mixture was heated for about one hour the supernatant liquid became clear and the precipitation was completed. The supernatant liquid was poured off, leaving the precipitate, which was then washed by decantation with hot ethyl alcohol until the washings were found to be free of chlorides. The precipitate was then washed with ether, placed on filter paper, and dried in a vacuum desiccator. The melting point was from 150.1 to 151.7° C.

The salt was analyzed by igniting and converting it into magnesium oxide. The residue was moistened with concentrated nitric acid and again ignited. This process was repeated several times in order that all the magnesium salt would be converted into magnesium oxide.

Analysis:

	Magnesium. Per cent.
Calculated for $C_{36}H_{62}Br_8O_4Mg$	1.99
Found	2.10

Manganese salt of alpha linolic tetrabromide.—Five grams of the potassium salt of alpha linolic tetrabromide were dissolved in 150 cubic centimeters of methyl alcohol. To this solution was added a hot methyl alcohol solution of manganous chloride containing a slight excess of the calculated quantity of crystallized manganese chloride ($MnCl_2.4H_2O$). A pinkish white flocculent precipitate was obtained immediately. The mixture was heated for about one hour to complete the precipitation. The clear

supernatant liquid was poured off, leaving the precipitate, which was washed by decantation with hot methyl alcohol until free of chlorides. The precipitate was then washed with ether, placed on filter paper, and dried in a vacuum desiccator. The melting point was 144.9 to 147.5° C.

The salt was analyzed by igniting and converting the manganese into mangano-manganic oxide[13] (Mn_3O_4). A weighed portion of the salt was ignited in a platinum crucible and heated until the weight was constant.

Analysis:

	Manganese. Per cent.
Calculated for $C_{36}H_{62}Br_8O_4Mn$	4.38
Found	4.35

Melting point.—A determination of the melting point of the salts that were prepared showed that the cadmium, cobalt, copper, magnesium, and manganese salts gave fairly constant melting points for long-chain compounds. This seems to be rather unusual since, according to the literature,[14] several salts of long-chain aliphatic acids do not give a sharp melting point.

Solubility.—Qualitative solubility experiments on the salts that were prepared were made at room temperature (about 30° C. and designated as cold), and also in hot solvents. For low-boiling solvents like acetone, the solubility in hot solution was determined at the boiling temperature of the solvent. With high-boiling solvents, such as benzyl alcohol, the temperature for solubility determination was about 90° C. In reporting the qualitative solubility data, the term "soluble" is used for solvents that dissolved the salt to the extent of about 1 to 4 per cent. For solubility below 1 per cent the terms "insoluble" or "slightly soluble" are used. The term "very soluble" is used when about 5 per cent or more of the salt is dissolved.

As shown by the solubility data given in Table 1, the salts of alpha linolic tetrabromide that were prepared in this research are not very soluble in the ordinary organic solvents. Experiments showed that 100 cubic centimeters of benzene dissolved 5.6 grams of the copper salt. One hundred cubic centimeters of chloroform dissolved 6.7 grams of cadmium salt and 11.6

[13] Watt's Dictionary of Chemistry 3 (1912) 181.

[14] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes 1 (1921) 156, 157, 160, 163, 172, 175, 191, 192, 200, 204, 207; Beilstein's Handbuch der Organischen Chemie, Vierte Auflage, 2 (1920) 361, 369, 372, 374, 395, 396, 466, 473.

grams of the copper salt. One hundred cubic centimeters of ethyl benzoate dissolved 5.3 grams of the cadmium salt and 4.1 grams of manganese salt.

TABLE 1.—*Solubility of salts of alpha linolic tetrabromide.*

[I, insoluble; ss, slightly soluble; S, soluble; VS, very soluble.]

Solvent.	Cadmium salt.		Cobalt salt.		Copper salt.		Magnesium salt.		Manganese salt.	
	Cold.	Hot.	Cold.	Hot.	Cold.	Hot.	Cold.	Hot.	Cold.	Hot.
Acetone	I	ss	I	I	I	I	I	I	I	I
Amyl alcohol	ss	S	------	------	I	I	I	ss	I	ss
Benzene	ss	ss	I	I	ss	S	I	I	I	ss
Benzyl alcohol	ss	ss	I	ss	ss	S	I	ss	------	------
Carbon tetrachloride	I	ss	I	I	ss	ss	I	ss	I	ss
Chloroform	ss	S	I	I	S	VS	I	I	I	ss
Ether	I	ss	I	I	I	I	I	I	I	I
Ethyl alcohol	I	ss	I	I	I	ss	I	I	I	ss
Ethyl acetate	I	I	I	I	I	ss	I	ss	I	ss
Ethyl benzoate	ss	S	I	I	------	------	ss	ss	ss	S
Ethyl bromide	ss	ss	I	ss	ss	ss	I	ss	ss	ss
Isopropyl alcohol	I	I	I	I	I	ss	I	I	I	ss
Methyl alcohol	I	I	I	I	I	I	I	I	I	I
Propyl alcohol	I	ss	I	I	I	I	I	I	I	I
Petroleum ether	I	I	I	I	I	I	I	I	I	ss
Toluene	I	I	I	I	ss	S	I	ss	I	ss
Xylene	I	I	I	I	ss	S	I	ss	I	I

These solubility experiments indicate that chloroform is the best solvent for the copper and cadmium salts. Ethyl benzoate is the best solvent for the manganese salt, and it is also a good solvent for the cadmium salt. The cobalt and magnesium salts were found to be only slightly soluble in a few solvents.

SUMMARY

Alpha linolic tetrabromide (melting point, 112.3 to 114.3° C.) was prepared from lumbang oil.

The potassium salt of alpha linolic tetrabromide was prepared by treating an alcoholic solution of the free acid with an alcoholic solution of potassium hydroxide.

From the potassium salt of alpha linolic tetrabromide the cadmium, cobalt, copper, magnesium, and manganese salts were prepared.

The melting point of each of these compounds was determined, and the formulas were checked by analysis.

The solubility of all of these salts was determined for various solvents.

THE BITTER PRINCIPLE OF MAKABUHAY, TINOSPORA RUMPHII BOERLAGE [1]

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Of the plants in the Philippines which contain bitter principles, *Tinospora rumphii* Boerlage is of considerable interest because it is reputed by the Filipinos to possess diversified medicinal properties; hence its Tagalog name *makabuhay*, meaning literally "that which brings back life." The plant is a vine and is widely distributed in the Philippines.

It was first studied chemically by Bacon(1) who reported that he had examined a large quantity of the stem and found that the bitter aqueous extract of the stem does not contain an alkaloid. However, he detected some substances which, when boiled with acids, have reducing power in Fehling's solution. Since these substances occur in an amorphous and resinlike condition, and as they failed to produce any physiological effect on guinea pigs, it was not deemed advisable to devote further time to this plant. The absence of any physiologically active substance in the plant was also shown, according to him, when no apparent effect was noted by injecting very concentrated aqueous extract prepared from the plant into guinea pigs, both subcutaneously and intraperitoneally.

More recently, Feliciano(3) reinvestigated the plant, and be concluded that it contains berberine, a glucoside, and a bitter principle. However, the methods of testing for the presence of these constituents were qualitative in nature, so that the findings cannot be considered as definite. Of direct concern to the problem is the work of Flückiger(4) on *Tinospora cordifolia* Miers, a closely related species growing in British India and which is also reported to possess many different therapeutic properties.(2) In this plant Flückiger found a small quantity of alkaloid (traces of berberine) and a bitter principle which,

[1] Previous investigations on this plant were reported under the name *Tinospora reticulata* Miers.

when boiled with acids, also reduces Fehling's solution. However, neither the bitter principle nor the products derived from it could be crystallized.

As the data so far obtained on the chemical nature and mode of action of makabuhay are very meager, and considering that this plant is one of the plants indigenous in the Philippines esteemed for their medicinal properties, the need for further study becomes imperative. In view of the fact that in all probability the medicinal virtue of the plant, if any, is traceable to its bitter principle which had never been isolated, attention was first directed to the chemical study of this particular plant constituent. A quantitative chemical analysis of the plant is also under way and will be reported separately.

EXPERIMENTAL

Methods of extraction.—The material employed for this investigation consisted of the stems of wild plants growing in the vicinity of Manila. The bitter principle can be extracted from the fresh sliced stems, either with 95 per cent ethyl alcohol or with water, but water was used because alcohol removes a considerable amount of the green coloring matter. To hasten the extraction and to prevent the possible autolysis of the bitter principle, the material was boiled in distilled water with frequent stirring for about half an hour. While hot, the aqueous extract was decanted and, when necessary, the material was repeatedly treated with boiling water until all the bitter principle was extracted. The combined aqueous extracts were then filtered and, to effect the isolation of the bitter principle, the general scheme outlined for the extraction of bitter principles was applied. In several methods tried, the bitter principle could not be obtained, in either the crystalline or the amorphous state, entirely free of impurities. It was then decided to dialyze the aqueous solution in the hope of separating the gums and the mucilaginous substances from the bitter principle and the sugars. The dialyzate thus obtained was concentrated and then precipitated by tannic acid. The precipitate was mixed with lead carbonate, dried, and exhausted with alcohol. After removal of the alcohol there remained a brownish, intensely bitter, sirupy residue. To remove the color, the alcoholic residue was dissolved in water, heated to boiling with purified animal charcoal, and filtered while hot. The filtrate was still colored but was no longer bitter; hence, the bitter principle must have been absorbed by the charcoal. To recover the bitter principle, the

charcoal, after drying, was treated with warm 95 per cent alcohol, and the alcoholic solution obtained was evaporated. The bitter principle, although still found to occur in a resinous mass, was in a fairly purified state, as it was free from sugars and coloring matter. In the attempt to crystallize the bitter principle, this mass was treated in aliquot portions with several organic solvents, such as ether, carbon disulphide, ethyl acetate, acetone, and chloroform, and the solvents were allowed to evaporate spontaneously. It was observed that the bitter principle was only slightly soluble in these solvents, and did not appear in crystal form even after it was set aside for several days at room temperature or in the ice box. Finally, the effect of heating the bitter principle previously moistened with some of the solvents was tried; the portion that had been previously treated with chloroform was again moistened with a few cubic centimeters of the same solvent and heated on the water bath. This treatment proved rather satisfactory, for the bitter principle was converted into the form of white flakes, which can be reduced to powder.

While the experiments herein discussed indicate the possibility of isolating the bitter principle in question, the method as applied is defective because the separation of the mucilaginous substances by dialysis and the further treatment of the dialyzate with tannic acid are objectionable because it is necessary to add a preservative to the aqueous solution to be dialyzed, so that fermentation will be prevented, and also because tannic acid does not completely precipitate the bitter principle and is itself slightly soluble in alcohol. Consequently, from the various methods tried, a modified method was evolved which consists in evaporating the decoction of the fresh, sliced stems on a water bath and extracting the brownish mucilaginous residue with boiling 95 per cent alcohol until all the bitter principle is removed. The combined alcoholic solution was freed from alcohol by distillation under reduced pressure, and the extract left in the flask was treated with a large quantity of warm water and filtered through a suction flask; the deep brown aqueous solution was treated with enough lead subacetate to effect the separation of the tannin. The precipitate was discarded and sodium carbonate was then added to the filtrate to remove the excess of lead salt. After this treatment, the aqueous solution was boiled with purified charcoal, and the whole mixture was transferred into the suction flask while still hot and the charcoal washed several times with boiling water. The charcoal was dried and treated

with absolute alcohol. After recovery of the alcohol by distillation, the thick, oily, yellowish white residue was moistened with a few cubic centimeters of chloroform and evaporated on the boiling water bath; the bitter principle was then obtained in white flakes capable of being converted into an amorphous powder. The white bitter principle was further heated in a vacuum oven at 60° C. The yield represents about 0.17 per cent of the fresh sample, corresponding to 0.95 per cent of the moisture-free sample.

Properties.—The bitter principle occurs as a white, apparently crystalline powder, the bitter taste of which develops rather slowly, but is intense and persistent, and is deliquescent. It is freely soluble in alcohol, but very slightly soluble in other organic solvents, such as ether and chloroform. It dissolves slowly in water, giving an opalescent solution.

The alcoholic solution of the bitter principle is levorotatory and neutral to litmus. The melting point varies from 154 to 155° C. A colorless solution is produced on testing with concentrated nitric acid, hydrochloric acid, and acetic acid, but it becomes brown when tested with concentrated sulphuric acid.

The bitter principle reduces Fehling's solution only after treatment with acid, does not respond to the general tests for alkaloids, and is free from nitrogen and halogens. It is therefore a glucoside, possibly consisting of molecules of glucose with some aromatic groups. This statement is based on the fact that the products of the acid hydrolysis of the bitter principle have an aromatic odor and give glucosazone on the application of the osazone test.

Results of the elementary analysis show that the bitter principle consists of 41.15 per cent carbon, 11.67 per cent hydrogen, and 47.18 per cent oxygen, as shown by the following data:

I. 0.0563 gram sample gave 0.0588 gram water, and 0.0850 gram carbon dioxide.

$C = 41.17$ per cent.
$H = 11.68$ per cent.

II. 0.0565 gram sample gave 0.0589 gram water, and 0.0852 gram carbon dioxide.

$C = 41.13$ per cent.
$H = 11.67$ per cent.

SUMMARY

1. A proposed method for the isolation of the bitter principle of *Tinospora rumphii* Boerlage is described. This method can perhaps be applied to other plants yielding a bitter principle.

2. The bitter principle is glucosidal in nature. Its important physical and chemical properties have been determined.

3. The bitter principle consists of 41.15 per cent carbon, 11.67 per cent hydrogen, and 47.18 per cent oxygen.

ACKNOWLEDGMENT

I am indebted to Dr. Leon Ma. Guerrero, botanist of the Bureau of Science, for helpful suggestions and advice, and to Dr. W. H. Brown, director of the Bureau, for the deep interest he has shown during the progress of the work.

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NOTES ON THE ANALYSIS OF PHENOL (CARBOLIC ACID)

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An aqueous solution of carbolic acid, supposed to be exactly 5 per cent in strength, was submitted to this laboratory for analysis. It appeared that this solution, which was prepared by weighing the requisite quantity of Mallinckrodt United States Pharmacopœa gilt-label crystals in a precision balance, gave abnormal results when used in a certain biological experiment. It was, therefore, desired to know whether the content of phenol in the solution was, in fact, 5 per cent. The sample was analyzed in accordance with the procedure given by Sutton.[1] According to this author, this procedure is included in the United States Pharmacopœia and is a modification of the standard method of Koppeschaar. The results obtained by following Sutton would not agree, as can be seen from the following determinations:

	Phenol. Per cent.
I	3.38
II	2.88
III	2.67

It was obvious, from the wide discrepancy in results, that some anomaly had to be accounted for. A review of the literature was undertaken to ascertain the nature of the error involved. It was found that so much work had already been done on the subject of phenol tests that the field appeared to be particularly uninviting for further investigations. H. D. Gibbs,[2] of the United States Public Health Service Hygienic Laboratory, gives a classification of existing phenol tests and a fairly extensive bibliography of the subject.

The prevailing methods for the quantitative estimation of simple phenols involved:

I, Methods based on the formation of bromine derivatives.
II, Methods based on the formation of iodine derivatives.
III, Methods based on the direct titration with alkalies.

[1] Systematic Handbook of Volumetric Analysis, 11th ed. P. Blakiston's Son & Co. Philadelphia (1924) 405.
[2] Chemical Reviews III 3: 291.

In this paper no attempt is made to cover all of the methods in the above classification. From the standpoint of time, the methods under group I are by far the older, and the first to be evolved. The methods under group II find very limited application, since they meet with the serious objection that most phenols, when dissolved in alkalies, produce intensely colored solutions, and thus make it impossible to use chemical indicators. Recently, however, Bishop, Kertridge, and Hildebrand[3] demonstrated the feasibility of applying electrometric methods in determining the end point in the alkalimetric titration of phenol in alcoholic solutions. Considerable work has been done on the development of methods based on the formation of iodine derivatives. Analytical procedures have been devised by Messinger and Vortmann,[4] Fahrion,[5] Skirrow,[6] Inglis,[7] J. M. Wilkie,[8] and others. Since these methods have been found to be neither quite free from defects nor much more accurate than the earlier methods under group I, there has been in recent years a gradual reversion to the original method of Koppeschaar, which is based on the formation of bromine derivatives, and a movement has been launched to make the latter method the standard, particularly in the assay of nearly pure carbolic acid. I shall take up only those methods which are based on the formation of bromine derivatives, the method of Koppeschaar in particular. As it may prove of interest to the reader, a brief history of the development of the method of Koppeschaar is herewith included.

In 1871, H. Landolt[9] precipitated carbolic acid quantitatively from aqueous solutions by treatment with excess bromine water. The bromine derivative formed was found to be well-nigh insoluble in water, the reaction being indicated in as great a dilution as 1 part phenol in 43,700 parts water. Landolt dried his precipitated bromine compound over sulphuric acid and, from the weight of precipitate obtained, calculated the percentage of phenol. His results indicated the molecular weight of the precipitate to be 326 to 328, from which he deduced that the compound formed was tribromphenol (molecular weight, 331). Koppeschaar[10]

[3] Journ. Am. Chem. Soc. 44 (1922) 135.
[4] Berichte 23 (1890) 2753; Journ. Soc. Chem. Ind. 9 (1890) 1070.
[5] Zeitschr. angew. Chem. (1901) 1226.
[6] Journ. Soc. Chem. Ind. (1908) 58.
[7] Journ. Soc. Chem. Ind. (1908) 315.
[8] Journ. Soc. Chem. Ind. 30 (1911) 398.
[9] Berichte 4 (1871) 770.
[10] Zeitschr. f. Anal. Chem. 25 (1876) 162.

found Landolt's gravimetric method to be too tiresome; he characterized the process of filtering, washing, and drying the flocculent precipitate as "cumbersome and ceremonious." Therefore, he converted the original gravimetric method into a volumetric process by treating the solution of carbolic acid with a known volume of standard bromine water solution, the strength of which was so adjusted that it more than completely precipitated all the carbolic acid as tribromphenol. The excess of bromine in solution was then made to displace iodine from potassium iodide, and the iodine liberated was finally titrated back with standard sodium thiosulphate to the starch end point. The following reactions occurred:

$$C_6H_5OH + 3Br_2 \rightarrow C_6H_2Br_3OH + 3HBr$$
$$2KI + Br_2 \rightarrow 2KBr + I_2$$
$$I_2 + 2Na_2S_2O_3 \rightarrow Na_2S_4O_6 + 2NaI.$$

Considerable quantities of bromine vapor were lost by the use of bromine water solution as precipitant. Koppeschaar, therefore, substituted a solution of potassium bromide and potassium bromate, from which bromine could be evolved by treatment with sulphuric acid as follows:

$$5KBr + KBrO_3 + H_2SO_4 \rightarrow 3K_2SO_4 + H_2O + 3Br_2$$

Various attempts to simplify this method of Koppeschaar are recorded in the literature, but none appears to have prospered. It would not be amiss to mention a few instances here. E. Waller [11] titrated a solution of phenol containing saturated alum in dilute sulphuric acid with standard bromine water solution until the supernatant liquid in the titration vessel remained permanently yellow after agitation. P. Degener [12] ran a titration similar to Waller's, but used starch-potassium iodide-paper to indicate the end point. Giacosa [13] added standard bromine water to the aqueous solution of phenol until the supernatant liquid commenced to turn starch-iodide paper blue. Chandelon [14] added dilute phenol solution to potassium hypobromate until the liquid no longer acted on starch-iodide paper. Seubert [15] prepared a solution of potassium bromide and potassium bromate

[11] Chem. News **43**: 152.
[12] Journ. f. Prak. Chem. **17** (1878) 390.
[13] Zeitschr. f. Phys. Chem. **6**: 45.
[14] Bull. Soc. Chem. **38** (1882) 75.
[15] Arch. d. Pharm. (3) **18**: 321.

of known bromine content. This solution was then treated with either hydrochloric acid or sulphuric acid, and the phenol solution run in until the bromine was all consumed; starch-zinc-iodide paper was used as indicator. This method of Seubert was adapted by the Pharmacopœia Germanica, old edition, in the determination of acidum carbolicum liquefactum. O. Schlikum [16] made a critical study of the method of Seubert and found that, by running the solution of phenol into the beaker holding the bromine solution, appreciable amounts of bromine vapor were lost through evaporation. The use of glass-stoppered flasks in the titration tended to minimize but not to exclude errors from this source. Even when the titration was run in the reverse order, and potassium bromide-potassium bromate was titrated into the acidified carbolic acid solution, the loss of bromine was still considerable. In view of these circumstances, Schlikum suggested a conversion of Koppeschaar's bromine method into an iodimetric process.

So much for the history of the development of the method of Koppeschaar. Suffice it to say that in recent years there has been a movement to make this method a standard one.

The anomalous results obtained by following Sutton, as mentioned earlier in this paper, are connected with the fact that Sutton gives an erroneous quotation of the method as outlined in the United States Pharmacopœia IX–X. In the original procedure given there the manipulations involved can be briefly summarized as follows:

In the glass-stoppered flask of 500 mils capacity, the aqueous solution of phenol, containing not less than 0.038 gram nor more than 0.041 gram of carbolic acid, is treated with a volume of standard potassium bromide and potassium bromate solution calculated to give bromine in moderate excess over that required for the complete precipitation of the phenol. Five mils of concentrated hydrochloric acid are then run in, to liberate the bromine. The flask is closed and allowed to stand for half an hour, with occasional shaking, in order that all of the phenol may be acted upon and be converted into the bromine derivative. After half an hour, the flask is slowly opened, to prevent loss of bromine, and 5 mils of a 20 per cent solution of potassium iodide introduced. The mixture is shaken for a while, and the flask is then opened and its stopper and sides are washed with water. One mil of chloroform is then added to dissolve the precipitate

[16] Pharm. Zeit. (1884) No. 46.

and liberate occluded iodine, and the solution titrated to the starch end point with standard sodium thiosulphate. In the procedure by Sutton, however, it is directed to add potassium iodide immediately after the addition of hydrochloric acid. By so doing, the liberated bromine does not completely precipitate all of the phenol, but rather proceeds to displace iodine from the potassium iodide which has just been introduced. The amount of iodine liberated in this case is therefore greater than it should be, and the results obtained are, consequently, too low. The erroneous quotation in Sutton's procedure may have been due to an oversight; but, in a book that has gone through eleven revised editions, the mistake has no excuse for being and cannot well be overlooked. This is all the more so when, by the oversight, serious mistakes may be incurred and much time lost to the analyst in trying to locate the trouble and rectify matters. On the same page of Sutton's book, directions are given for the use of 1 gram of sample of carbolic acid, when the volume of potassium bromide and potassium bromate solution required by the procedure will barely furnish enough bromine to cause the precipitation of 0.2 gram phenol.

Koppeschaar's method is usually performed at the room temperatures of temperate climates (about 20° C.). At this temperature, concentrated hydrochloric acid evolves bromine from potassium bromide and potassium bromate at a moderate rate, but at the room temperature in the Philippines, which is about 30° C., the reaction has been noticed to be rather too vigorous, resulting in a visible escape of bromine vapors from the reacting system. This is particularly the case when the potassium bromide and potassium bromate solution has been prepared by treating caustic alkali with liquid bromine. From such a solution bromine is apparently more readily evolved than from one made by dissolving weighed amounts of chemically pure potassium bromide and potassium bromate.

I have found in a series of experiments performed that, when 12-normal sulphuric acid or sirupy phosphoric acid was used instead of concentrated hydrochloric acid, the liberation of bromine proceeded much more slowly, and consequently the loss of bromine vapor was greatly minimized. The use of phosphoric acid is of further advantage in that it does not liberate iodine from potassium iodide as much as does concentrated hydrochloric acid. The latter acid, when placed in contact with potassium iodide for five minutes, which is about the time required to run a titration, liberates sufficient iodine to give the blue iodo-

starch coloration.[17] It was found convenient to run the titrations in flasks especially designed for the determination of the iodine number. These flasks are provided with widely flared-out lips, which can hold about 5 cubic centimeters of potassium iodide, so that, when the stopper is pulled out, any escaping bromine fumes are trapped by the inflow of potassium iodide. The following tabulated results show the effect of using different acids in liberating bromine from the bromide-bromate solution:

EXPERIMENT I

Acid used.	Phenol. Per cent.
Concentrated hydrochloric acid (HCl), 12 *N*	4.94
Sulphuric acid (H_2SO_4), 12 *N*	4.97
Phosphoric acid (H_3PO_4), sirupy (Squibb)	4.97
Theoretical percentage of phenol (assuming the phenol used to be 100 per cent pure)	5.00

EXPERIMENT II

Acid used.	Quantity of phenol. g.
Concentrated hydrochloric acid (HCl), 12 *N*	0.0396
Sulphuric acid (H_2SO_4), 12 *N*	0.0398
Phosphoric acid (H_3PO_4), sirupy (Squibb)	0.0398
Theoretical amount of phenol	0.0399

These results indicate that, by the use of sirupy phosphoric acid or 12-normal sulphuric acid, values closer to the theoretical are obtained. However, phosphoric acid is preferable, as the heat produced by its solution is less than in the case of sulphuric acid. When glacial acetic acid was used, no visible evolution of bromine from the bromide-bromate solution was noticed for a day or so, but at the end of forty-eight hours the white precipitate of tribromphenol was formed, which showed that glacial acetic acid also evolved bromine from the bromide-bromate solution, but at too slow a rate to be of much use in the volumetric determination.

The assumption of Landolt and Koppeschaar, that the precipitate formed by the action of bromine on carbolic acid is tribromphenol, has been questioned on good grounds. Benedikt[18] stated that the precipitate obtained was tribromphenolbromide ($C_6H_2Br_3OBr$) and not tribromphenol ($C_6H_2Br_3OH$), as given by Landolt. Weinreb and Bondi[19] analyzed the precipitate obtained by the action of excess bromine on carbolic acid and

[17] Compare with Diehl, Dingler's Polytech. Journ. **246** (1882) 196.
[18] Wien. Ak. Ber. 2 (May, 1879).
[19] Monatshefte f. Chem. **6**: 506.

found its composition to conform with that calculated for tribromphenolbromide. It would seem from these results that the method of Koppeschaar, which assumes that the compound formed is tribromphenol and not tribromphenolbromide, was built on false premises. However, it was shown by Weinreb and Bondi that, even had tribromphenolbromide been formed along with tribromphenol proper, this was of no consequence, for tribromphenolbromide acted on potassium iodide with the liberation of two atoms of iodine; so that, as Beckursts [20] points out, the original assumption of Koppeschaar, that 6 atoms of bromide entered into combination with 1 mole proper of phenol is, in practice, still correct. Landolt, in his gravimetric estimation of phenol, assumed the precipitate to be exclusively tribromphenol. If tribromphenolbromide is also formed, how came Landolt by his results? Some authors have criticized and discredited his experiments.

Some gravimetric determinations were run in the laboratory of the Bureau of Science and it was found that, with the present-day facilities of the modern laboratory, the gravimetric process is not so tedious as it was once thought to be. The amount of time and attention required for running a gravimetric determination is not much more (if anything, it is less) than that required by the volumetric method of Koppeschaar. While it is true that the precipitate of the bromine derivative is voluminous it, nevertheless, has the property of coagulating into flocks which are readily filtered through a Gooch crucible. Washing the precipitate is made easy by the use of suction, which has the further advantage of eliminating any excess of bromine vapor by the free passage of sucked air. The filtered precipitate dries to constant weight when left in a vacuum desiccator over sulphuric acid for from three to four hours, at most overnight. The following gravimetric determinations were performed:

An aliquot portion of a solution, which was made exactly 5 per cent in carbolic acid by weighing pure phenol crystals, was treated with saturated bromine water solution, with constant shaking, until a permanent yellow coloration, due to moderate excess of bromine, became visible on the supernatant liquid of the precipitation vessel. The precipitate was then filtered through a weighed Gooch crucible, washed with the aid of suction, and then dried to constant weight over sulphuric acid in a vacuum desiccator.

[20] Arch. d. Pharm. III 24 (1886) 561.

RESULTS

The percentage of phenol obtained by assuming the precipitate to be only tribromphenol was:

	Per cent.
First trial	5.19
Second trial	5.26

The same results, recalculated on the assumption that tribromphenolbromide and not tribromphenol had been formed, showed:

	Per cent.
First trial	4.19
Second trial	4.24
Percentage of phenol by Koppeschaar's method	4.97
Theoretical percentage of phenol (assuming the phenol used to be 100 per cent pure)	5.00

These results show that, if the gravimetric precipitate is assumed to be only tribromphenol, the values obtained are slightly higher than they should be theoretically whereas, if assumed to be tribromphenolbromide alone, the values obtained are far too low. It would seem from these results that the precipitate was mostly tribromphenol with an admixture of tribromphenolbromide.

The experiment was repeated, using a much lower excess of saturated bromine water as precipitant, with a view of preventing as much as possible the formation of tribromphenolbromide from taking place. The results in this case were as follows:

The percentage of phenol obtained by assuming complete precipitation as tribromphenol only was:

	Per cent.
First trial	4.74
Second trial	4.72

These results differ from the result obtained by the volumetric method (4.97 per cent) by being lower by 0.2 per cent. It seems highly probable that in this case practically no tribromphenolbromide had been formed, but, in trying to use too small an excess of bromine water, some phenol may have been lost through incomplete precipitation. Beckursts [21] has already shown that the formation of either tribromphenol or tribromphenolbromide depends in a large measure on the manner of adding the precipitant, as well as on the conditions of precipitation. The addition of a large excess of bromine in the cold and without agitation, according to Beckursts, favors the formation of tribromphenolbromide.

[21] Loc. cit.

With a view of trying to form tribromphenolbromide exclusively, the following experiment was performed. To an aliquot portion of the 5 per cent phenol solution employed in previous determinations, saturated bromine water was added in large excess. The precipitation was carried in the cold, and with no agitation. The solution was then left to stand overnight before filtering. The precipitate was washed several times with the mother liquor, then with dilute bromine water, and finally with small quantities of water. Results were as follows:

The percentage of phenol calculated on the assumption of complete precipitation as tribromphenolbromide exclusively was:

	Per cent.
First trial	4.30
Second trial	4.28

Recalculation on the assumption of the formation of tribromphenol alone showed:

	Per cent.
First trial	5.33
Second trial	5.30

In this experiment, by far the greater portion of the precipitate is tribromphenolbromide, but tribromphenol is probably likewise present and in quantity sufficient to vitiate results. In this connection the attention of the reader is called to some experiments by Autenrieth and Beuttel.[22] These authors described the properties of tribromphenolbromide. They found the compound to be reduced to tribromphenol by the action of such reducing agents as hydroiodic acid, sulphurous acid, nascent hydrogen, etc. In a series of gravimetric determinations of a purified sample of carbolic acid, they precipitated the bromine derivative and computed the percentage of phenol on the basis of complete transformation into tribromphenolbromide. In some of their experiments, results ranging from 96.28 to 97.57 per cent were obtained. These results are from 1 to 2 per cent too low. The precipitate of tribromphenolbromide in these experiments was probably contaminated with tribromphenol formed by the decomposition of tribromphenolbromide. In spite of the low results, Autenrieth and Beuttel concluded that the method could be used for the analysis of phenol in cases where a high degree of accuracy is not requisite.

[22] Arch. d. Pharm. 248 (1910) 117.

In another series of experiments performed in the laboratory of the Bureau of Science a carbolic acid solution was prepared by weighing exactly 3.99 grams of Mallinckrodt gilt-label crystals in a precision balance and dissolving the weighed portion in distilled water to make a liter of solution. Ten cubic centimeters of this solution were treated with 50 cubic centimeters potassium bromide-potassium bromate solution of a strength more than sufficient to liberate bromine in excess of that required for the complete precipitation of all the carbolic acid. Five cubic centimeters of sirupy phosphoric acid were then added and the mixture was shaken until the bromine derivative was completely precipitated and the liquid in the precipitation vessel was permanently yellow. The precipitate was then filtered, washed, dried, and weighed. The color of the dried precipitate was distinctly white, which seemed to indicate, in a qualitative manner at least, that by far the greater part of the precipitate was tribromphenol. (Tribromphenolbromide is lemon yellow in color.) Sirupy phosphoric acid was used to liberate bromine from potassium bromide-potassium bromate. Results were as follows:

Experiment:	Quantity of phenol computed from tribromphenol. g.
I	0.0327
II	0.0352

When concentrated hydrochloric acid was used instead of sirupy phosphoric acid to liberate bromine the results were:

Experiment:	g.
III	0.0346
IV	0.0342
Volumetric (Koppeschaar)	0.0398
Theoretical weight of phenol (assuming the phenol used to be 100 per cent pure)	0.0399

The experiments were repeated but in this instance the precipitate formed was washed with an acidified solution of potassium iodide, in order to decompose tribromphenolbromide should this compound have been formed along with the tribromphenol. The following results were obtained:

Experiment:	Weight of phenol. g.
I	0.0336
II	0.0337
III	0.0339
IV	0.0343

The results of the above determinations check nicely, but the values obtained are far below the theoretical values. There is much probability that in these experiments tribromphenolbromide had not been formed. The filtrates in all of the above determinations were tested for unprecipitated carbolic acid with negative results. To what, then, may the low results be attributed? If the acid used to liberate bromine from the bromide-bromate solution is of no effect on the precipitated tribromphenol, then the next possibility points to the probable formation of compounds of lower molecular weight than that of tribromphenol, a conjecture which needs verification.

The observation noted in this paper can now be summarized as follows:

1. In working with aqueous solutions of nearly pure carbolic acid, the volumetric method of Koppeschaar is fairly accurate, but the process should be modified to suit local conditions. The use of sirupy phosphoric acid instead of concentrated hydrochloric acid to liberate bromine from potassium bromide-potassium bromate minimizes the possibility of error and gives results which are closer to the theoretical.

2. While the gravimetric determination is as easily performed as is the volumetric process, still the results obtained are not so accurate (too low). The main trouble in gravimetric determinations lies in the difficulty of precipitating either tribromphenol or tribromphenolbromide to the exclusion of the other.

3. Attention is called to some errors on page 405 of the eleventh revised edition of Sutton's A Systematic Handbook of Volumetric Analysis (1924).

4. A brief history of the development of the method of Koppeschaar is given.

ACKNOWLEDGMENT

These notes are published at the suggestion of Dr. T. Dar Juan, of the Bureau of Science, to whom I am indebted for valuable suggestions and kindly criticisms.

NOTES ON CEBU COALS

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Several papers have appeared in the Philippine Journal of Science and in the Mineral Resources of the Philippine Islands regarding the peculiar characteristics of Philippine coals. As the samples used were from the outcropping or upper beds, it is generally held that Philippine coals will improve with depth. Cox[1] stated:

> in time it is expected that a much better quality of coal will be developed from the lower beds, as is indicated by the drill sample analyses.

He also pointed out[2] that the Philippine coals used were from the upper or outcropping beds,

> in which naturally the percentage of ash and especially of moisture, due to climatic conditions, is higher than the average.

It is not known how the coal samples used for analysis were obtained, although the results for the lower seams on Batan Islands, Albay Province, were from drill samples.

These notes present the results of analyses made on coal samples, obtained according to the generally accepted directions, in order that the true nature and quality of native coal under actual mining conditions can be shown. The samples used in this report were collected by Mr. Frank A. Dalburg, formerly of the division of geology and mines, Bureau of Science, when he was mining engineer and geologist for the National Coal Company; and by me when I was detailed as mining engineer and geologist for the Cebu Portland Cement Company. The samples were collected after the manner prescribed in Technical Paper No. 1, United States Bureau of Mines.

The samples in Table 1 were collected from different parts of the National Coal Company mines at Mount Licos, Cebu, and represent Philippine coal in this particular district under actual mining conditions. It will be remembered that four

[1] Philip. Journ. Sci. 1 (1906) 886.
[2] Op. cit. 900.

TABLE 1.—*Analyses of coal samples from Licos mines, Cebu* [a]

[Numbers indicate percentages.]

Sample from—	Moisture at 105° C.	Volatile combustible matter.	Fixed carbon.	Ash.	Sulphur (S), separately determined.	Coking quality.	Color of ash.	Total, or gross calories.
Enriqueta seam, Tunnel No. 6:								
No. 1	8.77	43.10	44.94	3.19	0.46	Noncoking	Light brown	6,982
No. 2	10.29	38.39	47.80	3.52	0.42	do	Brown	6,454
Enriqueta seam, Tunnel No. 7:								
No. 3	12.48	36.80	48.02	2.70	0.37	do	Reddish brown	6,612
No. 4	8.07	33.29	39.98	18.66	0.39	do	Light brown	5,395
Enrique Abella seam, Tunnel No. 7:								
No. 5	10.15	40.29	41.89	7.67	0.40	do	do	6,513
No. 6	9.40	39.10	42.71	8.79	0.45	do	do	6,251
Esperanza seam, Tunnel No. 7:								
No. 7	10.66	40.18	46.44	2.72	0.34	do	Brown	6,903
Carmen seam, outcrop:								
No. 8	8.71	40.66	45.29	3.39	0.45	do	Reddish brown	6,574

[a] Analyzed by Francisco Peña.

seams were recognized here; namely, the Carmen, the Esperanza, the Abella, and the Enriqueta. These are named from west to east; that is, from lowest to highest. All the seams strike in the same general direction, north 23° east, and dip about 40° to the southeast.

It will be noted by referring to Table 1 that, while sample 8 is an outcrop sample, its heating value is higher than that of sample 2 from Tunnel No. 6, sample 4 from Tunnel No. 7, and samples 5 and 6 from the Enrique Abella seam in Tunnel No. 7, although the difference is slight. The heating value varies from 5,395 calories for sample 4 to 6,982 for sample 1, with the outcrop sample giving 6,574 calories.

It will be noted also that the moisture content of the outcrop sample is lower than that of all of the other samples except 4; the difference in moisture between the outcrop sample and No. 4 is 0.64 per cent. From these results it is safe to conclude that the percentage of moisture is not lower in the deeper beds.

The fuel ratio, or the quotient of the fixed carbon divided by the volatile matter, in the outcrop sample is greater than in sample 1 from the Enriqueta seam in Tunnel No. 6 and in samples 5 and 6 from the Enrique Abella seam in Tunnel No. 7, but is less than in sample 2 from the Enriqueta seam in Tunnel No. 6, samples 3 and 4 from the Enriqueta seam in Tunnel No. 7, and sample 7 from the Esperanza seam in Tunnel No. 7.

The ash content is fairly low. While inert matter in a coal is detrimental to the total number of heat units, the ash in Philippine coals has given but little trouble. At any rate, the ash content in the outcrop sample is lower than in sample 4 from the Enriqueta seam and in samples 5 and 6 from the Enrique Abella seam and, even if sample 4, which has 18.66 per cent ash, is not taken into account, is still much lower than the average.

The samples in Table 2 were collected from the mines at Mount Uling, Cebu, and the results are indicative of the nature and the quality of the coal in the district under actual mining conditions. Disregarding the coking seams, which cannot be used for purposes of comparison, it is seen that the moisture content of the outcrop sample is less that that of sample 96 of the Margarita seam and that it exceeds that of sample 55 from the same seam by 0.11 per cent. The moisture content

TABLE 2.—*Analyses of coal samples from Uling mines, Cebu.*[a]

[Numbers indicate percentages.]

Sample from—	Moisture at 105° C.	Volatile combustible matter.	Fixed carbon.	Ash.	Sulphur (S), separately determined.	Coking quality.	Color of ash.	Total, or gross calories.
Margarita seam, West Tunnel No. 3:								
No. 96	15.02	39.47	32.17	13.34	0.73	Noncoking	Reddish	4,993
No. 55	14.10	41.25	33.91	10.74	0.26	do	Brownish pink	5,054
Coking seams, Margarita Tunnel No. 2:								
No. 1	4.85	42.17	49.41	3.57	2.53	Soft-coking	do	7,178
No. 4	8.58	39.13	47.86	4.43	0.43	do	Brick red	6,827
Tunnel near Sugimoto:								
No. 93	17.55	40.10	37.06	5.29	0.49	Noncoking	Brownish	5,506
Bernardo's Tunnel:								
No. 77	12.27	45.32	37.58	4.83	0.32	do	Brownish pink	5,703
Outcrop sample:								
No. 14 [b]	14.21	41.40	36.69	7.70	1.70			5,248

[a] Analyzed by Eusebio F. Gutierrez.

[b] From Table III, Outcrop and upper-bed coals of Cebu, Philip. Journ. Sci. 1 (1906) 881.

of the outcrop sample is much less than that of the sample taken from a tunnel near Sugimoto's workings, although it is greater by 1.94 per cent than that of the sample taken from Bernardo's tunnel.

The samples from the Margarita seam show a greater percentage of ash content, while the samples from the tunnel near Sugimoto and Bernardo's have less.

The total heating value of the outcrop sample, 5,248 calories, places it upon a sort of middle ground between the samples from the comparatively low Margarita seam and those from the other two localities.

The results of the analyses made from these samples can be considered representative of the Cebu coals; those in Table 1 are from the Danao–Compostela field and those in Table 2 are from the Mount Uling field. The samples were collected after the manner prescribed in Technical Paper No. 1 of the United States Bureau of Mines, and the methods used were exactly the same. The results obtained not only give the nature of the Cebu coals (which are practically all subbituminous) under actual mining conditions, but also confirm the findings of Cox [3] regarding the uniformity in the composition of most Philippine coals, barring diluents, water, ash, and sulphur.

The results of the analyses given in Tables 1 and 2 are further summarized as follows:

1. Philippine coals, as typified by Cebu coals, do not improve with depth.

2. The percentages of ash and moisture, which it has been claimed would improve as the beds extend deeper underground, are not lower than the average.

3. The analysis of a properly collected sample on the outcrop would show the nature and the general quality of the seam at the depths at which it would be mined.

[3] Philip. Journ. Sci. § A 7 (1912) 1.

COMPARATIVE STRENGTH PROPERTIES OF THE PRINCIPAL PHILIPPINE COMMERCIAL WOODS [1]

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ONE PLATE

INTRODUCTION

Wood has been one of the primary materials of engineering construction since earliest times; no efforts have been spared in civilized countries in studying its strength properties. On account of its nonhomogeneous character, it is far more difficult to determine the proper and most economical wood to use in certain construction than it is to decide upon other building materials, such as iron and steel, masonry, or concrete. It is not unusual to find that certain valuable species of wood are employed unnecessarily, because even a crude knowledge of their strength is not available.

Despite the fact that many kinds of wood are found in Philippine forests, only a very few are at present of commercial importance. It has been estimated that there are close to three thousand species of trees that reach a diameter of 30 centimeters or more. Luis J. Reyes, wood technologist of the Philippine Bureau of Forestry, estimated that more than six hundred distinct species are cut for timber, but only about two hundred have been observed in the markets at one time or another. In general, from forty to fifty species are available in the larger markets, but in practice less-known timbers are included and sold as well-known species or as "miscellaneous," which practice reduces the number of commercial timbers to from fifteen to twenty.

The increasing scarcity of some of the more durable and stronger species makes it imperative to find others which, by virtue of their strength, durability, and other properties, can be used in place of some of the more valuable species. Hence

[1] This work was undertaken in coöperation with the Bureau of Forestry and was made possible through the generosity of the local lumber companies, who furnished the greater part of the lumber used in the tests.

a knowledge of the strength characteristics of Philippine woods is of the utmost importance from the standpoint of economy and proper utilization of the timber resources.

DISCUSSION OF RESULTS

The specimens tested represent typical material obtained from the principal lumber regions in the Archipelago. The majority were identified from botanical material obtained from the tree; a few of the better-known species were purchased from the local lumber dealers, but were critically compared with authentic specimens in the working collection of the Bureau of Forestry. It is to be regretted that it was not possible to have a complete

TABLE 1.—*List of the timbers tested.*

Common name.	Scientific name.	Family.
Akle	*Albizzia acle* Merr	Leguminosæ.
Aimon	*Shorea eximia* Scheff	Dipterocarpaceæ.
Amamanit	*Eucalyptus deglupta* Bl	Myrtaceæ.
Amugis	*Koordersiodendron pinnatum* Merr	Anacardiaceæ.
Apitong	*Dipterocarpus grandiflorus* Blco	Dipterocarpaceæ.
Aranga	*Homalium luzoniense* F. Vill	Flacourtiaceæ.
Bagtikan	*Parashorea plicata* Brand	Dipterocarpaceæ.
Bansalagin	*Mimusops parvifolia* R. B	Sapotaceæ.
Banuyo	*Wallaceodendron celebicum* Koord	Leguminosæ.
Batete	*Kingiodendron alternæfolium* Merr	Do.
Benguet pine	*Pinus insularis* Endl	Pinaceæ.
Dao	*Dracontomelum dao* Merr. and Rolfe	Anacardiaceæ.
Dungon	*Tarrietia sylvatica* Merr	Sterculiaceæ.
Guijo	*Shorea guiso* Bl	Dipterocarpaceæ.
Ipil	*Intsia bijuga* O. Ktze	Leguminosæ.
Kalamansanai	*Neonauclea calycina* Merr	Rubiaceæ.
Lamog	*Planchonia spectabilis* Merr	Lecythidaceæ.
Lumbayao	*Tarrietia javanica* Bl	Sterculiaceæ.
Malugay	*Pometia pinnata* Forst	Sapindaceæ.
Manggachapui	*Hopea acuminata* Merr	Dipterocarpaceæ.
Manggasinoro	*Shorea* sp	Do.
Mayapis	*Shorea palosapis* Merr	Do.
Molave	*Vitex parviflora* Juss	Verbenaceæ.
Narig	*Vatica mangachapoi* Blco	Dipterocarpaceæ.
Narra	*Pterocarpus indicus* Willd	Leguminosæ.
Nato	*Palaquium luzoniense* Vid	Sapotaceæ.
Pagatpat	*Sonneratia caseolaris* Engl	Sonneratiaceæ.
Pahutan	*Mangifera altissima* Blco	Anacardiaceæ.
Palosapis	*Anisoptera thurifera* Bl	Dipterocarpaceæ.
Pototan	*Bruguiera* sp	Rhizophoraceæ.
Red lauan	*Shorea negrosensis* Foxw	Dipterocarpaceæ.
Supa	*Sindora supa* Merr	Leguminosæ.
Tangile	*Shorea polysperma* Merr	Dipterocarpaceæ.
Tindalo	*Pahudia rhomboidea* Prain	Leguminosæ.
White lauan	*Pentacme contorta* Merr. and Rolfe	Dipterocarpaceæ.
Yakal	*Hopea basilanica* Foxw	Do.

TABLE 2.—*Adaptability numbers; strengths of timbers in terms of strengths of red lauan, or "Philippine mahogany," air-dry.*

[This table has been prepared from results of tests on structural sizes ranging from 2 inches by 4 inches by 6 feet to 8 inches by 8 inches by 12 feet. "Adaptability as a strut," "Shear parallel to grain," and "Hardness" are from small, clear specimens. The values for Douglas fir and white ash were taken from Bulletin 556 of the United States Forest Service.]

Common name.	Density.	Strength as a beam.	Stiffness as a beam.	Toughness as a beam.	Adaptability as a strut.	Shear parallel to grain.	Hardness.
Red lauan	100	100	100	100	100	100	100
Almon	90	100	100	80	110	100	110
Apitong	120	110	110	90	105	110	135
Aranga	155	130	120	130	160	155	310
Bagtikan	105	105	95	100	110	110	125
Guijo	150	150	90	125	140	140	200
Lumbayao	100	100	95	100	100	110	120
Manggasinoro	85	75	70	55	85	95	110
Nato	115	75	85	65	85	110	140
Pahutan	100	70	90	45	115	130	190
Palosapis	105	95	90	85	90	105	125
Supa	130	135	110	105	-------	-------	-------
Tangile	100	100	100	100	95	95	105
White lauan	95	95	95	95	100	100	120
Yakal	170	170	150	160	150	155	305
Douglas fir	80	130	80	175	125	95	110
White ash	115	240	120	460	200	220	300

description of the trees, as regards habitat, manner of growth, and position of specimens in the original trunk.

No attempt is made in this paper to place certain species above others in importance and it should be borne in mind that comparisons are strictly of strength values. Strength data are not sufficient to permit determination of species to be used in certain instances, because other properties, such as resistance to attack of "anay" (termites) and fungi, ability to take a good finish, staining qualities, ease of working, etc., must be taken into account. It is thus advisable to be cautious in the use of results reported in this article.

Tables 2 and 3 show comparisons of the different species of timber of structural sizes in terms of red lauan, or Philippine mahogany, which comprises about 90 per cent of our timber exports. It is well known that, even in simple bending, so many factors are involved in the determination of strength that no high degree of accuracy should be expected from these tabulated ratios. In the actual computations 5 per cent was chosen as the limit of accuracy, because for all practical purposes greater precision is not required.

TABLE 3.—*Adaptability numbers; strengths of timbers in terms of strengths of red lauan, or "Philippine mahogany," green.*

[This table has been prepared from results on structural sizes ranging from 2 inches by 4 inches by 6 feet to 8 inches by 8 inches by 12 feet. "Adaptability as a strut," "Shear parallel to grain," and "Hardness" are from small, clear specimens. The values for Douglas fir and white ash were taken from Bulletin 556 of the United States Forest Service.]

Common name.	Moisture.	Strength as a beam.	Stiffness as a beam.	Toughness as a beam.	Adaptability as a strut.	Shear parallel to grain.	Hardness.
	Per cent.						
Red lauan	48	100	100	100	100	100	100
Akle	98	105	80	160	115	255	215
Amamanit	52	130	130	70			
Amugis	46	170	120	135	185	340	270
Apitong	40	120	120	125	120	250	165
Aranga	31	130	130	115			
Bansalagin	40	180	130	150	185	365	365
Banuyo	61	140	135	160	145	285	200
Batete	52	140	130	85			
Benguet pine	26	95	105	90	110	205	125
Dao	42	145	120	95			
Dungon	47	140	110	125	130	325	360
Guijo	38	190	165	215	190	330	270
Ipil	49	200	165	320	245	375	320
Kalamansanai	43	165	145	130	180	350	305
Lamog	46	145	85	155	120	320	320
Lumbayao	35	120	110	115	120	230	135
Malugay	51	135	105	165	125	265	205
Manggachapui	38	200	170	210	245	340	260
Manggasinoro	36	80	85	40			
Mayapis	34	80	90	35	85	145	85
Molave	45	195	150	295	210	320	270
Narig	49	200	170	160	210	375	340
Narra	71	130	100	165	160	285	230
Pagatpat	53	150	90	165	160	295	245
Palosapis	61	125	115	150	120	240	145
Supa	34	120	110	125	120	300	225
Tangile	37	130	125	165	110	225	140
Tindalo	50	180	120	210	175	375	335
Yakal	36	210	170	260	220	405	380
Douglas fir	38	100	85	65	85	200	85
White ash	40	165	115	130	130	355	215

Up to a certain limit the strength of timbers varies in a fairly uniform manner with the moisture content; that is, the greater the moisture content, the less the strength. Beyond this limit the strength practically remains the same, however much the moisture is increased. At present no data are available for the determination of the limiting point in the case of Philippine timbers, and in this article a rough classification is made between "air dry" timbers (those containing from 8 to 22 per cent moisture) and "green" timbers (those containing above 30 per

TABLE 4.—*Strength values of air-dry timbers; standard clear specimen.*[a]

Common name.	Number of tests.	Moisture.	Specific gravity. At test.	Specific gravity. Oven-dry, based on volume at test.	Static bending. Fiber stress at elastic limit.	Static bending. Modulus of rupture.	Static bending. Modulus of elasticity.	Static bending. Longitudinal shear.	Static bending. Work to elastic limit.	Static bending. Work to maximum load.	Compression parallel to grain. Crushing strength at elastic limit.	Compression parallel to grain. Maximum crushing strength.	Compression perpendicular to grain. Crushing strength at elastic limit.	Shear parallel to grain.	Hardness; load required to embed a 1.12-cm. ball half its diameter. End.	Hardness; load required to embed a 1.12-cm. ball half its diameter. Side.
		Per cent			*kg. per sq. cm.*	*kg. per sq. cm.*	*1,000 kg. per sq. cm.*	*kg. per sq. cm.*	*kg. cm. per cu. cm.*	*kg. cm. per cu. cm.*	*kg. per sq. cm.*	*kg. per sq. cm.*	*kg. per sq. cm.*		*kg.*	*kg.*
Almon	112	17	0.59	0.50	490	725	127	26.0	0.102	0.978	355	390	55.6	79.4	295	326
Apitong	484	17	0.71	0.61	457	785	136	28.0	0.086	0.813	312	385	60.7	83.9	405	382
Aranga	72	13	0.94	0.83	692	1070	159	39.8	0.156	0.832	424	639	154	124	950	841
Bagtikan	60	16	0.65	0.57	484	785	122	27.8	0.105	0.861	334	383	65.3	88.3	352	372
Guijo	192	16	0.86	0.73	617	1,000	159	39.6	0.131	1.02	409	522	105	114	539	595
Lumbayao	128	17	0.64	0.56	392	750	112	27.7	0.091	0.711	273	394	62.0	87.3	373	331
Manggasinoro	76	15	0.51	0.44	359	580	97	22.1	0.081	0.643	239	314	47.2	78.0	348	279
Nato	64	17	0.69	0.56	385	707	104	25.6	0.082	0.638	248	331	71.7	89.9	419	380
Pahutan	36	18	0.81	0.65	433	819	137	27.5	0.087	0.499	340	430	75.2	106	597	517
Palosapis	104	15	0.64	0.54	378	716	109	25.4	0.078	0.757	266	328	58.4	86.1	365	355
Red lauan	248	17	0.60	0.51	420	679	112	24.5	0.089	0.776	303	366	52.7	80.7	295	287
Tangile	388	16	0.61	0.55	412	715	116	25.6	0.078	0.684	276	353	53.7	75.7	302	297
White lauan	212	17	0.59	0.50	414	715	117	25.5	0.088	0.826	309	361	48.4	80.9	387	304
Yakal	160	16	0.95	0.91	796	1,360	197	48.4	0.185	1.23	424	592	14.8	125	865	906

[a] Conversion factors:
kg. × 2.2046 = lb.
cm. × 0.3937 = in.
kg. per sq. cm. × 14.223 = lb. per sq. in.
kg.-cm. per cu. cm. × 14.223 = in.-lb. per cu. in.

TABLE 5.—*Strength values of green timbers; standard clear specimens.*[a]

Common name.	Number of tests.	Moisture.	Specific gravity.		Static bending.						Compression parallel to grain.		Compression perpendicular to grain. Crushing strength at elastic limit.	Shearing strength parallel to grain.	Hardness; load required to embed a 1.12-cm. ball half its diameter.	
			At test.	Oven-dry, based on volume at test.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Longitudinal shear.	Work to elastic limit.	Work to maximum load.	Crushing strength at elastic limit.	Maximum crushing strength.			End.	Side.
		Percent.			*kg. per sq. cm.*	*kg. per sq. cm.*	*1,000 kg. per sq. cm.*	*kg. per sq. cm.*	*kg.-cm. per cu. cm.*	*kg.-cm. per cu. cm.*	*kg. per sq. cm.*	*kg. per sq. cm.*	*kg. per sq. cm.*	*kg. per sq. cm.*	*kg.*	*kg.*
Akle	20	96	1.01	0.53	383	599	74	20.5	0.112	0.572	225	303	95.5	81.1	468	503
Amugis	20	43	1.04	0.73	491	817	117	29.2	0.127	1.03	324	488	95.5	108	530	678
Apitong	16	39	0.78	0.58	354	661	136	23.6	0.054	0.539	230	315	48.0	79.8	395	355
Bansalagin	16	39	1.06	0.76	582	968	130	32.8	0.147	1.07	374	466	114	115	817	814
Banuyo	16	60	0.95	0.60	477	758	121	27.2	0.101	0.941	303	350	60.1	90.4	445	446
Benguet pine	32	26	0.74	0.59	300	543	92	18.8	0.055	0.852	225	276	36.2	65.1	278	276
Dungon	16	46	1.13	0.77	436	753	96	27.0	0.113	1.01	239	353	96.1	103	767	866
Guijo	12	35	0.90	0.70	573	1,030	138	37.3	0.125	1.10	396	464	82.4	105	585	634
Ipil	32	46	1.10	0.75	710	1,050	143	37.8	0.194	1.16	515	586	110	119	676	756
Kalamansanai	12	36	0.93	0.69	607	968	129	34.6	0.159	0.988	363	450	110	110	712	656
Lamog	20	43	1.03	0.71	397	659	90	23.7	0.100	0.836	214	329	93.8	102	699	747
Lumbayao	12	37	0.70	0.56	306	608	96	21.9	0.053	0.639	223	311	53.9	72.3	313	294
Malugay	32	47	0.84	0.57	386	706	102	25.4	0.081	1.20	256	308	57.4	83.4	452	453
Manggachapui	20	40	0.88	0.62	686	1,100	150	38.3	0.177	1.32	523	563	89.2	107	611	564
Mayapis	8	38	0.46	0.38	299	474	87	17.0	0.057	0.879	154	229	25.8	46.6	200	181
Molave	16	40	0.99	0.71	576	937	131	33.6	0.141	1.09	430	499	100	102	581	626
Narra	32	58	0.82	0.52	491	776	101	27.7	0.135	1.03	322	387	68.1	89.9	526	507
Narig	8	44	1.09	0.75	774	965	162	34.5	0.183	0.682	414	530	116	118	773	756
Pagatpat	20	63	1.03	0.63	502	746	107	26.2	0.125	0.719	334	395	83.3	92.9	580	519
Pahutan	8	38	0.87	0.70	502	896	129	31.7	0.078	0.798	300	407	74.8	101	492	477

Patosapis	12	74	0.90	0.50	354	579	105	20.8	0.070	0.713	253	274	50.0	75.0	324	328
Red lauan	120	48	0.60	0.40	328	516	90	18.5	0.067	0.772	197	259	34.1	31.6	218	233
Supa	12	34	0.73	0.55	394	670	99	23.4	0.091	0.541	230	321	84.8	94.5	537	370
Tangile	52	37	0.69	0.53	293	604	104	21.6	0.050	0.576	205	298	42.2	70.7	302	308
Tindalo	16	50	1.14	0.77	542	856	112	31.0	0.151	0.846	343	453	121	119	728	779
Yakal	40	35	1.09	0.86	783	1,260	178	43.9	0.191	1.04	425	577	132	128	827	888

[a] Conversion factors:

kg. × 2.2046 = lb.

cm. × 0.3937 = in.

kg. per sq. cm. × 14.223 = lb. per sq. in.

kg.-cm. per cu. cm. × 14.223 = in.-lb. per cu. in.

cent moisture), except in the case of the Benguet pine which, although green, contains only 26 per cent. Those falling between 22 and 30 per cent moisture content are in the buffer class but, as the tables show, timbers that come within this class are an exception. It is very difficult to draw a sharp line between "air dry" and "green" timbers, so-called.

EXPLANATION OF TABLES

The following paragraphs explain the headings in Tables 2 and 3.

Density in terms of red lauan.—This is a comparison of the relative weights of the different species as found in the market, when air dry and when green.

Strength as a beam.—Here it is assumed that the fiber stress at elastic limit and modulus of rupture (these terms are defined at the end of this paper, play an equal part in the selection of two pieces of timber as regards strength as a beam. The assumption may not be quite accurate, but it is not an easy matter to say just what actually happens in a beam so unhomogeneous in character when subjected to bending. This is about the best measure available for purposes of comparison.

Stiffness as a beam.—This value is the modulus of elasticity and shows how much stress for each species is required to produce a unit strain.

Toughness as a beam.—Here the values for work to elastic limit have been made the basis of comparison. The greater the amount of work to bend to the elastic limit, the tougher the material under test. This again may not be quite an accurate assumption, but toughness is a term very difficult to define, and these values approximate it best.

Adaptability as a strut.—The values of compression parallel to the grain have been used for this factor.

Shear parallel to grain.—These figures are found by actually shearing the specimen parallel to the grain.

Hardness.—The values for both end and side hardness were used in this comparison.

Tables 4 and 5 give the mechanical properties of standard clear specimens; the former of air dry, and the latter of green pieces. In the preparation of the adaptability numbers the figures obtained for bending were not used, because small pieces scarcely play an important part in problems of actual construction. However, these figures are useful for purposes of com-

parison between species when the element of defects is reduced to a minimum.

TABLE 6.—*Strength values in bending of air-dry timbers; structural sizes from 2 inches by 4 inches by 6 feet to 8 inches by 8 inches by 12 feet.*[a]

Common name.	Number of tests.	Moisture.	Specific gravity.		Static bending.					
			At test.	Oven-dry, based on volume at test.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Longitudinal shear.	Work to elastic limit.	Work to maximum load.
		Per cent.			*kg. per sq. cm.*	*kg. per sq. cm.*	*1,000 kg. per sq. cm.*	*kg. per sq. cm.*	*kg.-cm. per cu. cm.*	*kg.-cm. per cu. cm.*
Almon	222	14	0.55	0.49	326	612	112	23.4	0.059	0.498
Apitong	202	16	0.72	0.62	364	647	127	25.6	0.064	0.501
Aranga	45	16	0.92	0.79	455	724	140	27.9	0.094	0.386
Bagtikan	90	15	0.62	0.54	356	619	107	25.1	0.074	0.512
Guijo	108	17	0.89	0.76	470	925	103	35.4	0.092	0.742
Lumbayao	35	18	0.61	0.52	348	540	110	25.1	0.072	0.505
Manggasinoro	62	15	0.51	0.44	245	474	83	15.2	0.041	0.337
Nato	54	15	0.68	0.59	269	447	97	16.4	0.047	0.234
Pahutan	40	12	0.60	0.54	247	396	102	13.7	0.033	0.178
Palosapis	60	14	0.63	0.55	301	591	103	22.7	0.063	0.434
Red lauan	130	18	0.60	0.51	353	582	115	24.2	0.073	0.427
Supa	24	14	0.78	0.68	418	884	125	35.5	0.077	0.759
Tangile	271	16	0.60	0.52	337	617	113	23.7	0.071	0.502
White lauan	134	15	0.58	0.50	328	545	107	22.0	0.069	0.427
Yakal	78	20	1.03	0.86	555	1,010	171	41.9	0.115	0.724

[a] Conversion factors:
kg. × 2.2046 = lb.
cm. × 0.3937 = in.
kg. per sq. cm. × 14.223 = lb. per sq. in.
kg.-cm. per cu. cm. × 14.223 = in.-lb. per cu. in.

Tables 6 and 7 give the actual strength values of structural-size specimens. These are greatly affected by the manner of growth of the tree, the portion from which the piece comes, whether or not they include knots and other defects, and the position of such defects in the specimen.

These structural pieces are generally what can be secured in the markets, and strength values obtained from them have a practical importance. An examination of these values and those obtained from small specimens show that the latter are lower, which is to be expected, and the choice of a proper factor of safety for certain uses is discretional with the engineer.

TABLE 7.—*Strength values in bending of green timbers; structural sizes from 2 inches by 4 inches by 6 feet to 8 inches by 8 inches by 12 feet.*[a]

Common name.	Number of tests.	Moisture.	Specific gravity.		Static bending.					
			At test.	Oven-dry, based on volume at test.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Longitudinal shear.	Work to elastic limit.	Work to maximum load.
		Per cent.			*kg. per sq. cm.*	*kg. per sq. cm.*	*1,000 kg. per sq. cm.*	*kg. per sq. cm.*	*kg.-cm. per cu. cm.*	*kg.-cm. per cu. cm.*
Akle	9	79	1.10	0.56	294	417	77	21.1	0.106	0.330
Amamanit	5	52	0.86	0.58	332	555	128	20.1	0.048	0.386
Amugis	10	46	1.03	0.71	447	718	115	27.2	0.091	0.620
Apitong	14	40	0.82	0.60	338	499	115	24.4	0.083	0.434
Aranga	6	31	0.99	0.76	372	512	127	17.6	0.077	0.211
Bansalagin	4	40	1.03	0.77	480	765	126	28.8	0.102	0.513
Banuyo	4	61	0.84	0.52	384	576	129	31.8	0.106	0.650
Batete	10	52	0.76	0.50	371	590	128	19.8	0.058	0.432
Benguet pine	8	35	0.65	0.49	258	388	101	21.4	0.060	0.432
Dao	4	42	0.84	0.59	375	624	118	22.5	0.065	0.505
Dungon	7	47	1.18	0.84	347	650	106	28.1	0.084	0.816
Guijo	7	38	0.92	0.67	536	777	158	42.3	0.145	0.706
Ipil	8	49	1.14	0.78	595	790	159	37.9	0.214	0.685
Kalamansanai	9	43	0.81	0.54	438	720	142	30.1	0.088	0.766
Lamog	8	46	1.04	0.71	385	594	84	20.0	0.104	0.552
Lumbayao	8	35	0.65	0.48	326	505	106	26.9	0.078	0.556
Malugay	8	51	0.66	0.44	367	530	110	29.5	0.110	0.427
Manggachapui	10	38	0.73	0.53	579	773	163	32.5	0.139	0.466
Manggasinoro	6	36	0.59	0.44	187	397	81	13.9	0.027	0.217
Mayapis	5	34	0.45	0.34	190	355	86	13.5	0.024	0.504
Molave	3	45	0.92	0.63	559	773	143	40.9	0.198	0.736
Narig	3	49	1.11	0.73	568	827	166	20.1	0.106	0.373
Narra	7	71	0.95	0.56	345	540	99	30.2	0.110	0.704
Pagatpat	10	53	0.89	0.57	396	620	87	21.9	0.110	0.585
Palosapis	16	61	0.86	0.54	319	556	109	23.9	0.099	0.468
Red lauan	31	58	0.62	0.39	265	431	97	23.6	0.067	0.473
Supa	5	34	0.92	0.69	314	485	108	26.3	0.083	0.256
Tangile	27	37	0.69	0.50	351	555	122	25.3	0.110	0.593
Tindalo	7	50	1.09	0.71	486	732	115	30.3	0.141	0.655
White lauan	5	45	0.65	0.41	241	431	87	19.2	0.049	0.481
Yakal	31	36	1.17	0.86	563	914	163	41.8	0.176	0.652

[a] Conversion factors:
kg. × 2.2046 = lb.
cm. × 0.3937 = in.
kg. per sq. cm. × 14.223 = lb. per sq. in.
kg.-cm. per cu. cm. × 14.223 = in.-lb. per cu. in.

METHOD OF TEST

Wherever possible, the standard methods of testing as used by the Forest Products Laboratory, Forest Service, United States Department of Agriculture, were followed.

To facilitate reference a brief outline of the methods is here included.

I. STANDARD CLEAR SPECIMEN

1. Static bending.
   - Size, 2 inches by 2 inches by 30 inches.
   - Span, 28 inches.
   - Loading, center.
   - Speed, descent of load, 0.225 inch per minute.
   - Plot, load against deflection.
   - Calculate:
     - Fiber stress at elastic limit.
     - Modulus of rupture.
     - Modulus of elasticity.
     - Longitudinal shear.
     - Work to elastic limit.
     - Work to maximum load.
2. Compression parallel to grain.
   - Size, 2 inches by 2 inches by 8 inches.
   - Distance between collars, 6 inches.
   - Speed, descent of load, 0.042 inch per minute.
   - Plot, load against deflection.
   - Calculate:
     - Crushing strength at elastic limit.
     - maximum crushing strength.
3. Compression perpendicular to grain.
   - Size, 2 inches by 2 inches by 6 inches.
   - Width of iron plate, 2 inches.
   - Speed, descent of load, 0.042 inch per minute.
   - Plot, load against deflection.

3. Compression perpendicular to grain—Continued.
   - Calculate, crushing strength at elastic limit.
4. Shearing parallel to grain.
   - Size, 3 inches by 3 inches by 2¼ inches.
     - Projecting lip, 2 inches by 3 inches by ¾ inch.
     - Shearing surface, 2 inches by 3 inches.
   - Speed, descent of load, 0.042 inch per minute.
   - Calculate, shearing strength.
5. Hardness.
   - Size, 3 inches by 3 inches by 2¼ inches.
   - Diameter of ball, 1.12 centimeters.
   - Speed, descent of load, 0.042 inch per minute.
6. Specific gravity and moisture content.
   - Size:
     - For static bending, 2 inches by 2 inches by 1 inch.
     - For compression parallel, 2 inches by 2 inches by 1 inch.
     - For compression perpendicular, 2 inches by 2 inches by 1 inch.
     - For shear parallel to grain and hardness, 2 inches by 3 inches by ¾ inch.
   - Calculate:
     - Specific gravity at test.
     - Specific gravity oven-dry.
     - Moisture percentage.

II. STRUCTURAL SIZES

1. Static bending.
   (*a*) Center loading.
      Size, 2 inches by 4 inches by 6 feet to 3 inches by 4 inches by 8 feet.
      Span, 60 inches to 90 inches.
      Speed, descent of load:
         Span less than 60 inches, = 0.225 inch per minute.
         Span more than 60 inches, = 0.18 inch per minute.
   (*b*) Third-point loading.
      Size, 4 inches by 6 inches by 8 feet and 4 inches by 8 inches by 15 feet.
      Span, 9 feet and 12 feet.
      Speed, descent of load, 0.18 inch per minute.
      Plot, load against deflection.

1. Static bending—Continued.
   (*b*) Third-point loading—Ctd.
      Calculate:
         Fiber stress at elastic limit.
         Modulus of rupture.
         Modulus of elasticity.
         Longitudinal shear.
         Work to elastic limit.
         Work to maximum load.
2. Specific gravity and moisture content.
   Size, cross section of specimen, 1 inch thick.
   Calculate:
      Specific gravity at test.
      Specific gravity, oven-dry.
      Moisture percentage.

DEFINITIONS OF TERMS USED

I. Static bending.
   1. *Fiber stress at elastic limit.*—This is the stress developed in the ouside fibers of the beam when loaded to its elastic limit. It is the greatest stress the timber can stand without permanent deformation.
   2. *Modulus of rupture.*—This is the stress in the outermost fibers of a beam at the instant of breaking, calculated on the assumption that the ratio of stress to strain is identical beyond as well as within the elastic limit. This assumption is theoretically erroneous, but may be used for comparison of the strength of the various species.
   3. *Modulus of elasticity.*—This is the ratio of stress to strain at any point up to the elastic limit. This is a measure of the stiffness of a beam.
   4. *Longitudinal shear.*—This is defined as the stress which tends to keep two adjoining surfaces of a beam from sliding upon each other when acted upon by two opposing parallel forces of equal magnitude.
   5. *Work to elastic limit.*—This is the amount of work a beam can take up in the course of bending it up to the elastic limit. It is a measure of the toughness of the beam.

II. Compression parallel to the grain.
1. *Crushing strength at the elastic limit.*—This is the greatest load per square centimeter that the wood can carry on its end up to the elastic limit.
2. *Maximum crushing strength.*—This is the greatest load per square centimeter that the wood can bear without beginning to break.

III. Compression perpendicular to the grain.
Crushing strength at the elastic limit.—This is the greatest stress that the specimen can stand, up to the elastic limit.

IV. Shear parallel to the grain.
Shearing strength.—This is the greatest stress required to cause one portion of the body of the specimen to slide over the other along the grain.

V. Hardness.
End hardness.—This is the load required to embed a 1.12-centimeter ball one-half of its diameter into an end surface or along the grain.
Side hardness.—This is the load required to embed a 1.12-centimeter ball one-half of its diameter into a side surface or perpendicular to the grain, either tangential or radial.

VI. Moisture percentage.
This is the moisture that the wood contains at the time of test, expressed as percentage of the oven-dry weight of the specimen.

VII. Specific gravity.
1. *Specific gravity at test.*—This is the specific gravity of a specimen at the time of test.
2. *Oven-dry specific gravity.*—This is the specific gravity of a piece of wood computed on the oven-dry weight and the volume when tested.

SUMMARY

Following the standard methods used by the Forest Products Laboratory, Forest Service, United States Department of Agriculture, mechanical tests were made on some Philippine commercial woods, both in structural sizes varying from 2 inches by 4 inches by 5 feet to 8 inches by 8 inches by 15 feet, and in smaller specimens free of knots and other defects, 2 inches by 2 inches by 30 inches. Tables of adaptability numbers were prepared giving a comparison of the suitability as regards strength of the different species with red lauan, or "Philippine mahogany," which is one of the best-known woods of the Islands.

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ILLUSTRATION

PLATE 1. STATIC BENDING, THIRD-POINT LOADING.

PHILIPPINE SPAROID AND RUDDER FISHES

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NINE PLATES

SPARIDÆ

Body oblong or more or less elevated and laterally compressed, covered with moderately large firm scales which are never truly ctenoid, soft dorsal and anal scaleless, sides of head usually scaly; head large, bony crests on skull usually well developed, bones of head with a rudimentary muciferous system; no suborbital stay; mouth small, terminal, low, horizontal; premaxillary not protractile; maxillary short, without a supplemental bone, slipping under edge of preorbital for most of its length; teeth strong, those in front of jaws conical, incisorlike, or molar; the lateral teeth may be conical and sharp, but are usually more or less blunt and molar, sometimes with several rows of very broad flat molars; no teeth on vomer or palatines except in *Evynnis*, a Japanese genus with a group on vomer, and *Neolethrinus*, an Australian group with molar teeth on roof of mouth; preopercle entire or serrulate; no opercular spines; dorsal fin single, continuous or deeply notched, spines usually strong, depressible in a groove or a scaly sheath; spines 10 to 13, heteracanthous or alternating, the one kind stronger on the right side, the other on the left; anal short, with 3 spines; ventral fins thoracic, I–5, with a more or less distinct scalelike appendage at base; air bladder usually simple; pyloric cæca few; gills 4, a large slit behind the last; pseudobranchiæ large; gill rakers moderate; gill membranes separate, free from isthmus; vertebræ usually 10 + 14.

A large group with numerous genera and many species. Carnivorous shore and reef fishes of tropical and temperate waters. Many of them are highly valued for food and they form the basis for important hand-line fisheries in Japan and Formosa. Four genera are known from the Philippines.

Key to the Philippine genera of Sparidæ.

a^1. Cheeks naked; dorsal X–9; anal III–8 .... **Lethrinus.**
a^2. Cheeks scaly.
  b^1. Molars in a single series in both jaws .... **Monotaxis.**
  b^2. Molars in two or more series.
    c^1. Molar teeth in two rows on each side of upper jaw .... **Pagrus.**
    c^2. Molar teeth in three, four, or five rows on each side of upper jaw. **Sparus.**

Genus LETHRINUS Cuvier

Lethrinus CUVIER, Régne Anim., ed. 2 2 (1829) 182.
Lethrinella FOWLER, Journ. Acad. Nat. Sci. Phila. (1904) 529.

The members of this genus are recognized at a glance by their naked cheeks, only the opercles being scaled; top of head also naked; body oblong, laterally compressed; all the species have the dorsal X–9, the anal III–8, and rather large scales, 46 to 50 in lateral series; anterior part of each jaw with 4 large conical canines, with a row of villiform teeth on their inner side; laterally each jaw has a single row of large conical or molar teeth, the posterior ones often with very flat broad crowns, unlike the teeth of most percoid fishes; angle of mouth red within; 2 or 3 short pyloric appendages; branchiostegals 6; air bladder generally notched posteriorly and with short lateral appendages.

These fishes feed upon crustacea, mollusks, coral, and other fishes. They reach a length of one-third of a meter to a meter, and most of them are valued for food. They are one of the principal sources of supply for the dried-fish industry at Sitankai. In Japan and Formosa enormous quantities are caught by hand-line and long-line fisheries. In the Philippines they are caught mainly in nets and bobos, but are not the basis of any special fishery.

Although it superficially resembles *Lutianus*, the genus is a very natural and easily recognized one, but most of the species are difficult to separate. Many nominal species have been named and described, most of them based upon immature and isolated specimens. The color, shape of the head, and general form often change greatly with age. Some of the species are brilliant red in life, and several have a black lateral blotch. In alcohol they fade to gray or brown, the black blotch may disappear, and upon quite diverse species mottled blotches may appear, causing them to resemble each other closely. Only careful examination of a large series of fresh mature specimens will clear up the muddled synonymy.

This genus occurs from the east coast of Africa to Japan and Polynesia, with one species on the west coast of Africa.

Key to the Philippine species of Lethrinus.

a^1. Lateral teeth conical.
 b^1. With a blackish lateral blotch.
  c^1. Blackish blotch below anterior dorsal rays and beyond pectoral. **L. moensi.**
  c^2. Blackish blotch more anterior and between lateral line and pectoral.
   d^1. Depth of body less than length of head.
    e^1. Second dorsal spine highest and filiform........ **L. nematacanthus.**
    e^2. Second dorsal spine not as above.
     f^1. Head rather long, 2.4 to 2.6 times in length of body; snout very elongate........ **L. miniatus.**
     f^2. Head rather short, 2.7 to 2.8 times in length of body; snout moderate........ **L. amboinensis.**
   d^2. Depth of body equal to or greater than length of head. **L. richardsoni.**
 b^2. Without any blackish lateral blotch.
  g^1. Body deep and fairly short, depth 2.7 times in length.
   h^1. With blackish crossbands on sides........ **L. cutambi.**
   h^2. Without any blackish crossbands on sides........ **L. kallopterus.**
  g^2. Body low and rather elongate, depth 3.1 to 4 times in length.
   i^1. Depth of body 3.6 to 4 times in length; with a blackish longitudinal band in young, and with or without blackish transverse blotches in adult........ **L. variegatus.**
   i^2. Depth of body 3.1 times in length; with 2 wide golden or yellowish longitudinal bands........ **L. ramak.**
a^2. Some of the lateral teeth rounded or with a distinct longitudinal impression.
 j^1. With a blackish lateral blotch.
  k^1. Blackish blotch between lateral line and middle of pectoral. **L. atkinsoni.**
  k^2. Blackish blotch between lateral line and posterior portion of pectoral........ **L. harak.**
 j^2. Without a blackish lateral blotch.
  l^1. Five scales above lateral line.
   m^1. Height of soft anal less than its length.
    n^1. A blackish spot at base of each scale; anterior profile of head steep, straight before eyes........ **L. haematopterus.**
    n^2. Color uniform, with six broad, clear crossbands; anterior profile very steep, slightly concave before eyes...... **L. mahsena.**
   m^2. Height of soft anal greater than its length........ **L. hypselopterus.**
  l^2. Six scales above lateral line.
   o^1. Head longer than deep; third anal spine higher than second.
    p^1. Scales on back and middle of sides with pearl white spots. **L. opercularis.**
    p^2. Scales on back and middle of sides without pearl white spots. **L. leutjanus.**

o^2. Head as deep as long; second and third anal spines about equal in height.

q^1. Body with five or six reddish or yellowish longitudinal bands. L. **ornatus.**

q^2. Body without bands.. L. **insulindicus.**

LETHRINUS MOENSI (Bleeker). Plate 1, fig. 1.

Lethrinus moensii BLEEKER, Nat. Tijd. Ned. Ind. 9 (1855) 435; GÜNTHER, Cat. Fishes 1 (1859) 455; Fische der Südsee 1 (1873) 64, pl. 46, fig. A; BLEEKER, Atlas Ichth. 8 (1877) 115; 7 (1876) 297, fig. 3.

Lethrinus moënsi EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 86; Proc. U. S. Nat. Mus. 31 (1907) 509; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1907) (1908) 259.

Lethrinus genivittatus PLAYFAIR, Proc. Zool. Soc. (1867) 853; not of Cuvier and Valenciennes.

Dorsal X–9; anal III–8; 47 scales on lateral line to base of caudal, 6 between lateral line and origin of dorsal, and 16 between lateral line and origin of anal.

Body oblong and compressed, with evenly arched profiles, upper more elevated, the depth 2.8 to 3.3 times in length; head much longer than deep, its length exceeding depth of body, 2.6 to 2.8 times in length; interorbital space nearly flat, 3.6 to 4.3 times in head; diameter of the large, almost circular eye 1.5 to 2 times in the long pointed snout, which is 1.8 to 2.2 times in length of head; maxillary extends posteriorly to below anterior nostril, its length 2.7 to 3 times in head and less than greatest width of preorbital, which is 2.1 to 2.4 times in head; four curved canines anteriorly in each jaw, those of upper much the larger, and a single row of pointed conical teeth on sides; in front of each eye two small nostrils, the anterior a fleshy tube which is highest behind, and the other a simple rounded opening; the opercle has two flat, blunt spines on its posterior border; least depth of caudal peduncle a little less than half its length and 8.9 to 9.9 times in length of body.

Two patches of scales behind eye, one on the uppermost portion of preopercle and the other on each side of nape; the dorsal spines decrease in height posteriorly from third, the last about as high as third anal spine, which is contained from 2.7 to 4.5 times in head; caudal fin forked, with pointed lobes; pectoral fin, which extends to above base of anal spines, shorter than head and about twice ventral spine; ventral fin reaches origin of anal fin.

Fresh specimens brownish, washed with pinkish on back and yellowish on sides, which passes into whitish along belly; head

yellowish brown, iris lemon yellow, inside of mouth bright red; the trunk has on each side transverse blackish blotches which are more bandlike along back; spinous dorsal edged with red, the colorless membranous portion having diagonal pinkish bands; rays of vertical fins, caudal, pectoral, and ventrals washed with pinkish, the membranous portions colorless; with the exception of pectoral, all fins above have series of blackish spots on rays.

Alcoholic specimens yellowish brown; top of head, snout, and cheeks deep violet; the body has irregular blackish blotches on sides, arranged in rather indistinct transverse bands; a large oblong blackish blotch below anterior half of soft dorsal and partly below lateral line; dorsal and anal fins have blackish spots at their bases, their rayed portions and caudal fin finely barred with the same color.

Of this species we have examined fifteen examples, varying from 28 to 196 millimeters in length, collected at the following localities: Legaspi, Albay; Calapan and Bulalacao Bay, Mindoro; Tablas Island; Romblon, Romblon Island; Dumaguete, Oriental Negros; Balabac Island; and Zamboanga, Mindanao. A specimen from Balabac Island measures 190 millimeters in length, and is a female nearly ready to spawn.

Evermann and Seale recorded *L. moensi* from Bacon, Sorsogon Province, and from Jolo Island; Jordan and Richardson recorded it from Calayan, one of the Babuyan Islands. It is common in nearly all parts of the tropical Pacific from the Moluccas to the Low Archipelago and north to the Gilbert and Pelew Islands and is found at the Seychelles in the Indian Ocean. It is said to reach a meter in length and its flesh is very good to eat.

LETHRINUS NEMATACANTHUS Bleeker. Plate 1, fig. 2.

Lethrinus nematacanthus BLEEKER, Nat. Tijd. Ned. Ind. **6** (1854) 403; Verh. Bat. Gen. **26** (1854) 90, pl. 6; GÜNTHER, Cat. Fishes **1** (1859) 456; BLEEKER, Atlas Ichth. **8** (1877) 114, pl. 337, fig. 3; MEYER, Ann., Soc. España Hist. Nat. **14** (1885) 18; EVERMANN and SEALE, Bull. Bur. Fisheries **26** (1907) 86; JORDAN and THOMPSON, Proc. U. S. Nat. Mus. **41** (1912) 559, fig. 4; WEBER, Siboga Exp., Fische (1913) 288.

Dorsal X–9; anal III–8; 46 scales on lateral line to base of caudal, 6 between lateral line and origin of dorsal, and 14 between lateral line and origin of anal.

The oblong compressed body a little elongate, its profiles evenly and about equally arched from snout to caudal; depth 3 to 3.2

times in length, a little less than length of head, which is much greater than its own depth and 2.8 to 3 times in length of body; interorbital space very slightly convex and contained from 3 to 3.9 times in head; diameter of the rounded eye 1.4 to 1.8 times in length of the pointed and slightly elongate snout which is 2.1 to 2.5 times in head; maxillary reaches to or nearly to vertical from anterior rim of orbit, 2.6 to 3 times in head, and almost as long as greatest width of preorbital; canines slightly curved and moderate in size; lateral teeth conical, becoming smaller and pointed anteriorly, more obtuse posteriorly; the two nostrils in front of each eye small, the anterior provided with a fleshy rim which is highest posteriorly, and the other a simple rounded opening; posterior edge of opercle armed with two flat spines, the lower much the stronger; least depth of caudal peduncle 8.5 to 9.2 times in length of body or 2.9 to 3.3 times in that of head.

Behind each eye two patches of scales, one above preopercle and the other on each side of nape; of the weak, rather flexible dorsal spines, the second is the highest and somewhat produced into a filament, which is 1.7 to 2.2 times in length of head; third anal spine a little longer than second and 2.9 to 3.5 times in head; caudal fin slightly emarginate; pectoral fin is rather short, 1.3 to 1.5 times in head, and extends to above anus; ventral fin reaches origin of anal, its spine 1.7 to 1.9 times in pectoral and 2.2 to 2.5 times in length of head.

The ground color in alcohol yellowish brown; head and body have irregular blackish spots, which are arranged in very indistinct transverse bands; a blackish blotch between middle portion of pectoral and lateral line; head almost uniformly violet; all fins excepting pectoral spotted with black.

The twenty specimens above described vary in length from 74 to 142 millimeters, and were collected at the following places: Calapan, Mindoro; Bulan, Sorsogon; Dicuayan Island, Busuanga; Estancia, Panay Island; Bantayan Island; Siquijor Island; Subic Bay; Dipolog and Cagayan de Misamis, Mindanao.

Dr. A. B. Meyer collected this species at Cebu and Evermann and Seale recorded it from Bulan, Sorosogon.

This species was originally described from southern Japan, where it is common; it ranges south through the Philippines to Amboina and southeastward to the Louisiade Archipelago.

LETHRINUS MINIATUS (Forster, MS.). Plate 1, fig. 3.

Sparus miniatus (Forster) BLOCH and SCHNEIDER, Syst. Ichth. (1801) 281.

Lethrinus miniatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 6 (1830) 235; GÜNTHER, Fische der Südsee 1 (1873) 63; BLEEKER, Atlas Ichth. 8 (1877) 121; STEINDACHNER, Sitzungsber. Akad. Wiss. Wien 115 (1906) Abt. 1, 1385; SEALE and BEAN, Proc. U. S. Nat. Mus. 33 (1907) 244.

Lethrinella miniata FOWLER, Journ. Acad. Nat. Sci. Phila. (1904) 529; JORDAN and SEALE, Bull. Bur. Fisheries 25 (1905) (1906) 270.

Lethrinus rostratus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 6 (1830) 220; GÜNTHER, Cat. Fishes 1 (1859) 454; DAY, Fishes of India (1875) 134, pl. 33, fig. 1; BLEEKER, Atlas Ichth. 7 (1876) pl. 309, fig. 3.

Lethrinus longirostris PLAYFAIR and GÜNTHER, Fishes of Zanzibar (1866) 44, pl. 7, fig. 2.

Dorsal X–9; anal III–8; 48 scales on lateral line to base of caudal, 6 between lateral line and origin of dorsal, and 16 between lateral line and origin of anal.

Body compressed and elongate, with the dorsal profile strongly elevated and the ventral slightly convex posteriorly, depth 2.8 to 3.2 times in length and much less than length of head; head rather pointed and compressed, its length 1.3 to 1.4 times its depth and 2.4 to 2.6 times in length of body, upper profile straight and strongly oblique, lower nearly horizontal; interorbital space slightly arched, its width 4.1 to 4.8 times in head; diameter of eye contained from 4.5 to 6.8 times in length of head and from 1.8 to 4 times in the very characteristic elongate pointed snout, which is 1.7 to 2.1 times in head; maxillary does not quite reach to below front nostril, its length 2.6 to 3 times in head and 1.4 to 1.7 times in snout; greatest width of preorbital equal to or more than twice that of interorbital space and 2.2 to 2.7 times in length of head; the teeth of the lateral series slightly compressed and pointed, the hindmost ones of upper jaw somewhat blunt and molarlike; the curved canine teeth rather small; two nostrils in front of each eye, the anterior smaller and in a low fleshy tube, the posterior a simple rounded opening; opercle armed behind with two blunt flat spines; depth of compressed caudal peduncle 9.7 to 10 times in total length and 3.9 to 4.2 times in head.

Two scaly patches behind eye, one on top of preopercle and the other a little more superior; second to fifth dorsal spines highest, the last contained 4.8 to 5.2 times in head; pectoral fin is 1.5 to 1.8 times in head and extends to above origin of anal fin; ventral fin reaches to anus, its spine 1.7 to 1.9 times in length of pectoral.

Fresh specimens were brownish, with lilac wash on sides which passed into whitish below; on each side of body there

were irregular, rather obscure deep brown transverse blotches; a large, rather distinct rounded blotch of the same color was present between lateral line and middle of pectoral; head darker than ground color, with deep brown bars running forward from eyes; caudal fin and the membranous portions of ventrals pinkish, the latter fin with the rays washed with lilac; the pectoral rays were pinkish, lilac basally; there were diagonal pinkish bands distinctly marked on the colorless membranes of dorsal and anal fins.

The ground color in alcohol yellowish brown; head, body, and fins clouded with blackish; a large blackish blotch between pectoral and lateral line; radiating from front edge of eye toward upper jaw three fine brown bands; a fourth crosses cheek from opercle to angle of mouth, and below this band are several brown blotches; vertical fins lightly banded with blackish, the base of some of the rays with a blackish spot.

The foregoing account is from thirteen examples, 74 to 460 millimeters long, taken at the following localities: Polillo Island; Manila; Calapan, Mindoro; Tablas Island; Bantayan Island; Subic Bay; Agutaya Island, Cuyo Islands; Dipolog and Zamboanga, Mindanao; and Tandubas Island, Sulu Archipelago.

This execellent food fish is a bold biter, and is often taken with the hook. It reaches a length of at least three-fourths of a meter. It occurs from the Red Sea to Samoa in the South Pacific.

LETHRINUS AMBOINENSIS Bleeker. Plate 2, fig. 1.

> *Lethrinus amboinensis* BLEEKER, Nat. Tijd. Ned. Ind. 6 (1854) 490; GÜNTHER, Cat. Fishes 1 (1859) 455; Fische der Südsee 1 (1875) 63; BLEEKER, Atlas Ichth. 8 (1877) 116; 7 (1876) pl. 311, fig. 3; JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907) 24; WEBER, Siboga Exp., Fische (1913) 288.
>
> *Lethrinus jagorii* PETERS, Monatsber. Akad. Wiss. Berlin (1868) 257.

Dorsal X–9; anal III–8; 47 scales on lateral line to base of caudal, 6 between lateral line and origin of dorsal, and 15 between lateral line and origin of anal.

The oblong, compressed body a little elongate, upper profile a little more elevated than ventral; depth contained 2.8 to 3 times in length; head longer than depth of body and 2.7 to 2.8 times in length; interorbital space almost flat, its least width 1.6 to 2 times in the rather pointed snout which is 2 to 2.5 times in head; the rounded eye moderate in size, its diameter 3.2 to 3.9 times in head and shorter than maxillary, which is contained 2.7 to 3 times and extends posteriorly to below posterior nostril;

the canines in front of each jaw moderate in size, the lateral teeth conical and not obtusely rounded; in front of eye two small nostrils, the anterior with a fleshy rim which is highest posteriorly, and the other a simple rounded opening; opercle has two flat bluntish spines at its posterior margin; depth of caudal peduncle 8.1 to 9 times in length of body.

Two patches of scales behind each eye, one above preopercle and the other just above it on side of nape; dorsal spines moderate and rather feeble, third to fifth spines the highest, tenth spine nearly as high as third anal, which is 3 to 3.5 times in head; caudal fin emarginate, with the lobes pointed; pectoral fin reaches to above base of anal spines and is 1.8 to 2 times ventral spine, which is contained 2.8 to 3 times in head; the rayed ventral terminates at about origin of anal fin.

Alcoholic specimens yellowish brown, head almost uniformly violet; a large rounded blackish blotch between lateral line and middle of pectoral; back and sides of trunk largely marbled with blackish; all the fins except pectoral, which is uniformly yellowish, variegated with blackish.

We have examined fifteen specimens, ranging in length from 131 down to less than 27 millimeters, from the following localities: Orani, Bataan; Tondo, Manila; Calapan, Mindoro; Bacon, Sorsogon; Concepcion, Busuanga; and Dipolog, Zamboanga. Jagor collected the species at Paracale, Camarines Norte, and Peters described it under the name of *L. jagorii*. Jordan and Seale recorded it from Cavite.

Lethrinus amboinensis is near to *L. reticulatus* and *L. variegatus*, but is closest to the first named.

It seems to be comparatively rare; Bleeker's specimens came from Amboina, Flores, and Ceram. In addition to specimens from Amboina, Günther had specimens from the Pelew Islands.

LETHRINUS RICHARDSONI Günther. Plate 2, fig. 2.

Lethrinus richardsoni GÜNTHER, Cat. Fishes 1 (1859) 456; JORDAN and EVERMANN, Proc. U. S. Nat. Mus. 25 (1903) 350; EVERMANN and SEALE, Bull. Bur. Fisheries 25 (1906) 86.

Lethrinus haematopterus RICHARDSON, Zool. Sulphur, Ichthy. part 3 (1845) 144, pl. 64, figs. 1–3, not of Schlegel; KNER, Reise Novara, Fische (1865) 80; BLEEKER, Atlas Ichth. 8 (1877) 113, note under *L. haematopterus* Schlegel.

Dorsal X–9; anal III–8; 46 or 47 scales on lateral line to base of caudal, 6 between lateral line and origin of dorsal, and 15 or 16 between lateral line and origin of anal.

Depth of the oblong compressed body contained from 2.4 to 2.8 times in length, dorsal and ventral profiles evenly and about

equally arched; the slightly pointed head longer than deep, shorter than depth of body, 2.6 to 3.1 times in length, its upper profile nearly straight; the slightly convex interorbital 3.6 to 4.2 times in head, or a little narrower than eye, which is 3.2 to 4 times in head; the pointed, rather elongate snout 2 to 2.3 times in length of head; maxillary ends posteriorly nearly below posterior nostril, its length 2.6 to 2.9 times in head and is slightly exceeded by preorbital's greatest width which is 2.2 to 2.6 times in head; each jaw has a single lateral row of conical teeth, which are rather small and acute anteriorly, moderately high along middle, and rather low and obtusely pointed behind; the curved canines at front rather small; anterior nostril in a low fleshy tube which is highest behind, and the other nostril is a simple rounded opening; the opercle has two flat, rather blunt spines at its posterior edge; depth of caudal peduncle 7.7 to 8.7 times in length of body.

Head naked except on opercles which are almost entirely scaled and behind each eye where there are two patches of scales, one above preopercle and another on each side of nape; dorsal spines moderate in height, fourth and fifth highest, the last one about as high as third anal spine which is 2.8 to 3.8 times in head; caudal fin emarginate; pectoral, which extends posteriorly to above base of anal spines, a little shorter than head and contained 3 to 3.5 times in length of body; ventral fin reaches to a little behind anus, its spine 2 to 2.3 times in length of pectoral.

Alcoholic specimens brownish olive, slightly darker on the naked portions of head; sides indistinctly marbled with blackish; a rounded blackish blotch between lateral line and anterior half of pectoral fin; pectorals and ventrals yellowish, the other fins indistinctly clouded with blackish, this color having faded in some specimens; caudal fin shows rather obscure transverse bars of blackish.

In the Bureau of Science collection are fifty-six specimens, varying from 32 to 192 millimeters in length. They were taken at the following localities: Iba, Zambales; Manila Bay; Calapan, Mindoro; Bacon, Sorsogon; Concepcion, Busuanga Island; Estancia, Panay Island; Bantayan Island; Carigara, Leyte; Canigaran, Palawan; Dumaguete, Oriental Negros; Surigao, Surigao; Cagayan de Misamis; Balabac Island; Loay, Bohol; Samal Island, Davao Gulf, Zamboanga, and Caldera Bay, Mindanao. There are also in the collection four examples, 62 to 94 millimeters long, obtained in Sandakan, Borneo.

This species has been recorded in the Philippines by Kner, as *Lethrinus haematopterus*, from Manila. It differs from *Lethrinus haematopterus* Schlegel in having all the lateral teeth in each jaw conical, pointed, and small. Evermann and Seale had twenty-five specimens from Bacon, Sorsogon. It has been recorded previously only from the China Sea, Hongkong, and Formosa.

LETHRINUS CUTAMBI Seale.

Lethrinus cutambi SEALE, Philip. Journ. Sci. § A 4 (1909) 514, pl. 10.

Dorsal X–9; anal III–8; 46 scales on lateral line to base of caudal, 5 between lateral line and origin of dorsal, and 15 between lateral line and origin of anal.

Upper profile of the oblong compressed body more elevated than lower, greatest depth at origin of ventrals, 2.7 times in length; head longer than deep, its length less than depth of body and 2.9 times in length; interorbital space convex, its least width equal to eye, which is 3.7 times in head; the elongate, slightly pointed snout 1.9 times in head, its upper outline concave; maxillary, which ends posteriorly below posterior nostril, 2.6 times in length of head and shorter than preorbital's greatest width, which is contained 2.2 times in head; 4 small canines in front of each jaw, the lateral teeth in each jaw conical, with the posterior ones obtusely pointed; anterior nostril has a marginal flap which is highest behind, and the other is a simple oval opening situated slightly nearer eye than anterior nostril; opercle armed behind with two flat blunt spines, the upper very small and scarcely noticeable; depth of caudal peduncle 8 times in length of body.

Head naked except on opercle and behind eye where there are two patches of scales, one above preopercle and the other on each side of nape; fourth dorsal spine highest, second anal spine slightly higher than last dorsal and contained 3.2 times in head; caudal fin deeply emarginate; pectoral fin shorter than head and contained 3.5 times in length of body, its tip above base of anal spines; ventral fin reaches anal opening, its spine 2.6 times in head or 2.2 times in pectoral.

Seale gives the color in life as dark greenish, with seven or eight irregular darker bars over the back and down the sides, and with the vertical fins marked with bars of dark green.

The color of the fish in alcohol is yellowish brown, with a slight shade of greenish; on each side are about eight darker greenish crossbars, which are narrower than the interspaces, running from the back to the ventral surface; the bars are

more or less broken at the lateral line but continuous below it; the blackish blotch on second bar between lateral line and middle of pectoral is hardly perceptible; the naked portions of head are brownish violet; there is a deep brown line at base of pectoral; dorsal and anal fins are indistinctly clouded with dark brown crossbars; pectoral fin is colored similarly to body.

Here described from the type specimen, No. 4678, now in the Bureau of Science collection. It is 159 millimeters in length and was collected at Sitankai, Sulu Archipelago, in July, 1908.

LETHRINUS KALLOPTERUS Bleeker. Plate 2, fig. 3.

Lethrinus kallopterus BLEEKER, Act. Soc. Sci. Indo-Neerl. 1 (1856) 47; GÜNTHER, Cat. Fishes 1 (1859) 460; BLEEKER, Atlas Ichth. 8 (1877) 113, pl. 351, fig. 3.

Dorsal X–9; anal III–8; 48 scales on lateral line to base of caudal, 6 between lateral line and origin of dorsal, and 15 between lateral line and origin of anal.

The oblong compressed body rather deep, its greatest depth equal to length of head, which is 2.7 times in length of body; profiles almost evenly and equally arched from snout to caudal; depth of head about equal to its length, upper profile, which is convex, prominently arched in front of and above eyes, giving a very slight concave outline to anterior half of snout; width of the moderately convex interorbital twice in the pointed snout or maxillary which is contained 1.9 times in head; diameter of the large rounded eye much less than width of interorbital and 4.2 times in length of head; greatest width of preorbital nearly twice eye and 2.2 times in head; posterior extremity of maxillary below anterior margin of orbit; in front of each jaw four large, slightly curved canines; on sides are conical teeth, those in front unequal and acutely pointed, the posterior teeth rather obtuse pointed; the two nostrils very small, the anterior in a low fleshy tube and the other rounded and placed closer to eye than to anterior nostril; two flat, rather blunt spines on posterior border of opercle; depth of caudal peduncle 2.9 times in length of head, or 7.6 times in that of body.

Behind each eye two patches of scales, a larger one above preopercle and the other higher up on each side of nape; third, fourth, and fifth dorsal spines highest, the tenth, which is higher than the preceding one, 4 times in head; third anal spine much higher than second and as high as last dorsal spine; rayed portion of anal much higher than long; caudal fin slightly emarginate, the lobes obtuse; pectoral fin extends to above base of anal spines, its length much less than that of head and 3.2 times

in length of body; ventral fin reaches anus, its spine 2.7 times in pectoral.

The fish when fresh was olive brown, with a pale center to each scale; there were golden spots scattered on the middle of the sides; the head was deep olive brown, with small, circular, golden spots on top and sides; all the fins were orange red; a few large golden spots scattered over the vertical fins and ventrals, and on the bases only of the other fins; both dorsal and anal vermiculated with bluish.

In alcohol the ground color olive brown, with a whitish center to each scale; head deep olive brown, with small circular pale spots on its sides and top; the vertical fins have become almost entirely deep violet, with some dark bands and pale spots; pectoral yellowish, ventral olivaceous, and caudal fin olive brown at its base and upper and lower portions and yellowish on the remaining portions; the red color on fins has almost entirely faded out; only traces remain of the golden spots on middle of sides.

This species is here described for the first time from the Philippines; our sole specimen is 350 millimeters long and was obtained at Tablas Island.

In common with *Lethrinus hypselopterus*, this species has the anal much higher than long, but is distinct in having the caudal lobes obtuse, while the coloration is unique in the genus.

This fine species has been recorded from Celebes, Batjan, and New Guinea.

LETHRINUS VARIEGATUS Ehrenberg. Plate 3, fig. 1.

Lethrinus variegatus Ehrenberg in CUVIER and VALENCIENNES, Hist. Nat. Poiss. 6 (1830) 213; BLEEKER, Atlas Ichth. 8 (1877) 117, pl. 328, fig. 3; pl. 330, fig. 2; 7 (1876) pl. 317, fig. 1; EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 86.

Lethrinus latifrons RÜPPELL, Neue Wirbelt., Fische (1840) 118, pl. 28, fig. 4.

Dorsal X–9; anal III–8; 46 scales on lateral line to base of caudal, 5 between lateral line and origin of dorsal, and 13 between lateral line and origin of anal.

Dorsal and ventral profiles of the compressed, rather elongate body evenly and equally arched from snout to caudal, depth 3.6 to 4 times, or exceptionally 3.2 times in length and much less than length of head; the pointed head much longer than deep, its length 1.6 times its depth and 2.7 to 2.9 times in length of body; interorbital space almost flat in the young and a little concave in the adult, its width 3.6 to 4 times in head, and slightly

less than the diameter of the large rounded eye, which is contained 3 to 3.4 times, or even 4 times in head in large specimens; the long pointed snout 2.4 to 2.7 times in length of head (1.8 times in a large specimen), its upper profile very slightly arched; maxillary, which terminates scarcely below anterior rim of eye, equal to or slightly less than greatest width of preorbital which is contained 2.6 to 2.9 times in head; the curved canines moderately large, and the lateral teeth conical, some of the latter enlarged and slightly curved backward; the two small nostrils closer together than the distance from hind one to eye, the anterior having a fleshy rim which is highest posteriorly and the other a rounded simple opening; opercle armed behind, with two flat spines; length of caudal peduncle about twice its least depth, which is 9.8 to 10.5 times in length of body.

A patch of scales above opercle behind eye and another just below nape; dorsal spines slender and not prolonged, fourth the highest and higher than soft dorsal, the last one about as high as third anal spine which is higher than second, 3.6 to 4 times in head; caudal fin forked; pectoral fin does not extend to above anus and is 1.6 to 1.9 times ventral spine, which is 2.8 to 3.1 times in head; ventral fin reaches anus.

In alcohol the ground color is yellowish brown, much paler on the lower parts; in a large specimen the body is crossed by rather indistinct bandlike transverse blackish blotches; in smaller specimens there is a longitudinal band of the same color from eye to upper half of caudal, and a yellowish, rather narrow longitudinal stripe following the anterior course of lateral line and separating the blackish band from the blackish brown color of back; rays of dorsal, anal, and caudal variegated with blackish brown.

The color pattern of this fish varies with respect to age. The young have a dark longitudinal band from each side of head to caudal; older specimens have on each side of body dark blotches arranged in rather indistinct bands, which disappear as the fish grows older.

The above account is of seven examples, 32 to 207 millimeters long, collected at Calapan, Mindoro; Canigao Island, Leyte; and Samal Island, Davao Gulf, Mindanao.

This species which has been recorded by Evermann and Seale from San Fabian, Pangasinan, occurs in the East Indian Archipelago and westward to the Red Sea and the coasts of Zanzibar and Mozambique.

LETHRINUS RAMAK (Forskål). Plate 9, fig 2.

Sciaena ramak FORSKÅL, Descr. Anim. (1775) 52.
Lethrinus ramak RÜPPELL, Neue Wirbelt., Fische (1840) 117, pl. 28, fig. 3; GÜNTHER, Cat. Fishes 1 (1859) 459; Fische der Südsee 1 (1873) 64, pl. 46, fig. B; BLEEKER, Atlas Ichth. 8 (1877) 119; MEYER, Ann., Soc. España Hist. Nat. 14 (1885) 19; JORDAN and SEALE, Bull. Bur. Fisheries 25 (1905) (1906) 269.
Lethrinus flavescens CUVIER and VALENCIENNES, Hist. Nat. Poiss. 6 (1830) 222.
Lethrinus ehrenbergii CUVIER and VALENCIENNES, Hist. Nat. Poiss. 6 (1830) 233.

Dorsal X–9; anal III–8; 48 scales on lateral line to base of caudal, 5 between lateral line and origin of dorsal, and 15 between lateral line and origin of anal.

Body oblong and compressed, dorsal and ventral profiles about equally elevated, depth 3.1 times in length and 1.2 times in head; the pointed head much longer than deep, its length 2.6 times in that of body and its upper profile rather prominently arched in front and above eyes; interorbital space is slightly convex, its least width 3.5 times in head, and greatly exceeds eye, which is 4.2 to 4.3 times in head; the elongate pointed snout a little concave above, its length twice width of interorbital, 1.8 times in head; maxillary is 1.4 to 1.5 times in snout or 2.5 to 2.7 times in head, and extends posteriorly to below anterior nostril; preorbital 2.3 times in length of head at its widest portion; teeth moderate in size; in front of each jaw four canines, the middle ones much the smallest; the lateral teeth conical, acute in front and more obtusely pointed behind; two small nostrils, the anterior having a fleshy rim which is highest behind, and the other is a simple rounded opening closer to eye than to anterior nostril; opercle armed on its posterior border with two flat spines; depth of caudal peduncle 10.2 to 10.4 times in length of body and 3.8 to 4 times in that of head.

Behind each eye two patches of scales, one above opercle and the other on each side of nape; third dorsal spine highest, nearly equal to ventral spine which is 2.9 to 3.1 times in head; third anal spine higher than second and very slightly higher than last dorsal which is 4.9 to 5 times in head; caudal fin emarginate, with pointed lobes, the upper slightly the longer; pectoral fin is 1.5 to 1.6 times in head and extends to vertical from anus; ventral fin reaches anus.

The ground color of the fresh fish was pale olive brown, the sides becoming gray which merged into whitish on breast and

belly; on each side of body were two broad longitudinal golden bands and a rather indistinct golden stripe on each row of scales; the trunk was traversed by irregular obscure bands of blackish olive; cheeks and snout were olive brown overlaid with reddish; portions of the very protractile premaxillary slipping under preorbital were bright red as were the tongue and the inside of mouth; there was a red bar at base of pectoral; the soft dorsal, top of spinous dorsal, and the margins of both anal and caudal were suffused with red or brilliant pink; the pectoral and ventral were pale pink; the dorsal had obscure reddish brown markings; the base of vertical fins had dark markings at the articulation of the rays.

In alcohol the ground color is olive brown, with two broad longitudinal yellow bands and narrow yellow stripes on each side of body; trunk traversed by irregular, rather indistinct, blackish bands, there being no definite lateral rounded or lateral blotch; the red and pink portions on fins, head, and inside mouth have almost faded out; the joints of vertical fin rays streaked with blackish; the naked portions of head deep olive brown.

Here described from two specimens from the Philippines, 255 and 270 millimeters long. They were taken at Tablas Island and Bennett Island, Masbate. Dr. A. B. Meyer collected this fish at Cebu.

Lethrinus ramak is rather rare in the Red Sea, where it was first collected. It occurs south along the coast of Africa to Zanzibar and ranges eastward in the Indian and Pacific Oceans to Celebes, the Pelew, Gilbert, Fiji, Samoa, and Tongatabu Islands.

LETHRINUS ATKINSONI Seale.

> *Lethrinus atkinsoni* SEALE, Philip. Journ. Sci. § A 4 (1909) 515, pl. 11.

Dorsal X–9; anal III–8; 47 scales on lateral line to base of caudal, 6 between lateral line and origin of dorsal, and 14 between lateral line and origin of anal.

The oblong, compressed body rather deep, the greatest depth at origin of ventrals and contained 2.5 times in length, the upper outline more elevated than the lower; length of head equal to its greatest depth and less than depth of body, 2.8 times in length; anterior dorsal profile of head in front of eye nearly straight; width of the slightly convex interorbital 3.4 times in head, the rounded eye rather large, its diameter 1.7 times in snout, which is contained 1.9 times in head; maxillary

ends posteriorly at the vertical from hind nostril, its length 2.6 times in length of head, and is exceeded by maxillary's greatest width which is contained 2.3 times in head; the four anterior canines in each jaw rather large, the lateral series composed of conical teeth in front and of large molars behind, each molar with a longitudinal groove; behind the canines a patch of minute teeth; anterior nostril very small and provided with a fleshy rim which is highest posteriorly; the other nostril is a simple ovate opening which is closer to anterior edge of eye than to front nostril; two flat, rather blunt spines on posterior edge of opercle, the upper very small and hardly noticeable; depth of caudal peduncle 3 times in head or 8.2 times in length of body.

Head naked except opercle and two patches behind eye, one above preopercle and the other on side of nape; dorsal spines moderate, third and fourth highest, the last one very slightly lower than third anal spine, which is contained 3.6 times in head; caudal fin deeply emarginate; pectoral, which is a little shorter than head, is 3 times in length of body and terminates posteriorly above base of anterior anal rays; ventral fin reaches origin of anal fin, its spine 2.4 times in length of pectoral.

According to Seale the color in life was yellow, with a slight wash of grayish; the fins colorless, excepting the ventrals which had dusky tips and the caudal which was yellow.

In alcohol it is yellowish brown, with the naked portions of head olive brown; middle of each row of scales above lateral line darker than ground color, making four or five narrow longitudinal lines which follow the curvature of back; a large, oblong, blackish blotch between lateral line and middle of pectoral fin; fins yellowish and unmarked, excepting first ray of pectoral which is grayish above, and ventrals which are dusky on posterior third.

The above account is that of the type specimen, No. 5080, which is now in the Bureau of Science collection. It measures 177 millimeters in length and was taken at Balabac Island in August, 1908.

This fish differs from *Lethrinus harak* (Forskål) and *Lethrinus bonhamensis* Günther in having the blackish lateral blotch placed a little more anteriorly.

LETHRINUS HARAK (Forskål). Plate 3, fig. 2.

Sciaena harak FORSKÅL, Descr. Anim. (1775) 52.

Lethrinus harak RÜPPELL, Neue Wirbelt., Fische (1840) 116, pl. 29, fig. 3; GÜNTHER, Cat. Fishes 1 (1859) 458; DAY, Fishes of India

(1875) 137, pl. 33, fig. 3; BLEEKER, Atlas Ichth. **8** (1877) 119, pl. 327, fig. 3; JORDAN and SEALE, Bull. Bur. Fisheries **25** (1905) (1906) 270; STEINDACHNER, Sitzungsber. Akad. Wiss. Wien **115**, Abt. 1 (1906) 1385; EVERMANN and SEALE, Bull. Bur. Fisheries **26** (1907) 86; SEALE and BEAN, Proc. U. S. Nat. Mus. **33** (1907) 244.

Lethrinus bonhamensis GÜNTHER, Fische der Südsee 1 (1873) 65, pl. 47; JORDAN and SEALE, Bull. Bur. Fisheries **25** (1905) (1906) 270; Proc. U. S. Nat. Mus. **28** (1905) 782.

Dorsal X–9; anal III–8; 47 scales on lateral line to base of caudal, 6 between lateral line and origin of dorsal, and 15 between lateral line and origin of anal.

Body oblong and compressed, dorsal and ventral profiles evenly and about equally arched, its depth 2.9 to 3 times in length; head a little longer than deep and almost as long as depth of body, its upper outline slightly swollen in front of eye; the slightly convex interorbital space widest anteriorly where there is a slight protuberance on each side before upper anterior angle of eye, its least width 3.6 to 4.1 times in head; the diameter of the rounded, rather large eye 2 to 2.3 times in head and 1.6 to 1.7 times in the moderately elongate and pointed snout, which is contained from 2 to 2.3 times in length of head; maxillary reaches to vertical from anterior nostril and is equal to or very slightly shorter than greatest width of preorbital which is contained 2.3 to 2.6 times in head; canines moderate in size, with a band of villiform teeth behind them in each jaw; the lateral series of teeth conical to obtusely pointed anteriorly, and posteriorly of rounded moderate to large molars, each with a longitudinal depression on its crown; in front of each eye two small nostrils, the posterior a simple oval opening closer to eye than to anterior nostril which has a low fleshy rim; posterior edge of opercle has two flat, rather weak spines; depth of caudal peduncle contained from 8.4 to 8.8 times in length of body.

Two patches of scales behind each eye, one on uppermost angle of preopercle and the other immediately above first; dorsal spines rather feeble, third to fifth highest and much lower than highest ray; last dorsal spine slightly lower than third anal, 3.1 to 3.7 times in head; caudal fin slightly emarginate; pectoral, which is shorter than head, is 3 to 3.3 times in length of body and extends almost to above base of anterior anal rays; ventral reaches to origin of anal fin.

The ground color of fresh specimens light greenish brown, lighter on the lower portions of body; a large, oblong, blackish

blotch on each side of body between lateral line and posterior half of pectoral; the membranous portions of dorsal colorless, irregularly barred with pinkish, the spines and rays greenish, spotted with grayish; caudal fin crossbarred alternately with very pale greenish and with pinkish; the membranous portions of the other fins colorless and the rays light salmon pink; inside of mouth red.

The ground color yellowish olive in alcohol; snout, cheeks, and top of head deep violet; on each side of body an oblong blackish blotch below lateral line and opposite posterior half of pectoral fin; in the young the sides are clouded with blackish brown.

We have examined the following series of specimens contained in the Bureau of Science collection, varying from 30 to 245 millimeters in length:

- Luna, La Union, 5.
- Iba, Zambales, 1.
- Manila Bay, 3.
- Puerto Galera, Calapan, and Pinamalayan, Mindoro, 10.
- Bacon, Sorsogon, 3.
- Bantayan Island, 1.
- Cebu, Cebu, 1.
- Canigao Island, Leyte, 1.
- Dumaguete, Oriental Negros, 3.
- Cagayan de Misamis, Misamis Province, 2.
- Canigaran, Palawan, 2.
- Balabac Island, 9.
- Zamboanga, Zamboanga, 2.
- Samal Island and Davao, Davao Province, 6.
- Tawitawi Island, Sulu Archipelago, 1.
- Subic Bay, 2.

The collection also contains three fine specimens from Guam.

Evermann and Seale recorded this species from San Fabian, Pangasinan; Bacon, Sorsogon; and Jolo, Sulu Province; Seale and Bean had it from Zamboanga.

Lethrinus harak was first collected in the Red Sea and is known eastward to Guam and Samoa.

We are unable to separate *L. bonhamensis* from *L. harak*, since our series shows every gradation between typical representatives of each. The specimens from Iba and Canigaran are typical of *bonhamensis* and have the following characters:

Depth 2.6 to 2.7 times in length, dorsal profile slightly more elevated than ventral; head slightly longer than deep, its length nearly equal to depth of body and 2.8 to 2.9 times in length; the diameter of the large rounded eye contained from 3.2 to 3.5 times in length of head; the moderately elongate and pointed snout 2.1 to 2.6 times in head, its upper outline very slightly concave; maxillary ends posteriorly below posterior nostril and is contained 2.5 to 3 times in head; greatest width of preorbital 2.4 to 2.8 times in head; canines and molars rather small; third

anal spine slightly higher than last dorsal spine, 2.9 to 3 times in head; caudal slightly forked; ventral fin reaches anal opening, its spine 2.4 to 2.6 times in head or 2 to 2.2 times in pectoral.

The ground color in alcohol varies from yellowish olive to brownish olive, with a large round blackish spot between lateral line and posterior third of pectoral; the sides of body in the young are indistinctly clouded with blackish; the fins colored like the body.

LETHRINUS HAEMATOPTERUS Schlegel. Plate 3, fig. 3.

Lethrinus haematopterus SCHLEGEL, Fauna Jap., Pisces (1842) 74, pl. 38; BLEEKER, Atlas Ichth. 8 (1877) 112, pl. 331, fig. 4; WEBER, Siboga Exp., Fische (1913) 288.

Dorsal X–9; anal III–8; 47 scales on lateral line to base of caudal, 5 between lateral line and origin of dorsal, and 14 between lateral line and origin of anal.

The deep, compressed body has the dorsal outline more strongly arched than the ventral, its greatest depth 2.4 to 2.5 times in length; head 2.8 to 2.9 times in length, almost as deep as long, upper profile rather steep and straight before eyes, the lower nearly horizontal; eye equal to or a little longer than the evenly convex interorbital, which is 3.4 to 3.8 times in length of head; the rather elongate and pointed snout 1.9 to 2 times in head and 1.2 to 1.3 times maxillary, the posterior end of which is directly below posterior margin of hind nostril; greatest width of preorbital 2.2 to 2.4 times in head and slightly greater than length of maxillary; mouth horizontal, lower jaw slightly included; canines moderate; anterior teeth of lateral series conical, becoming molars posteriorly, the latter with a distinct longitudinal impression on crown; two nostrils in front of each eye, the anterior small and tubular, the posterior a rather large, simple elongate opening; opercle has two flat bluntish spines at its hind margin; caudal peduncle deep and compressed, its least depth 2.8 to 3 times in head, 7.9 to 8.5 times in length.

Two patches of scales behind each eye, one above preopercle and the other just below nape; third, fourth, and fifth dorsal spines highest, the last one 3.3 to 3.7 times in head; anal spines graduated to the last which is highest, 3 to 3.6 times in head; the rayed portion of anal longer than high; pectoral is elongate and extends to above base of anterior anal rays, its length 2.9 to 3 times in length of body; ventral fin is 1.3 to 1.6 times in pectoral and reaches anus, its spine 1.4 to 1.7 times in its longest

ray; caudal slightly emarginate, with the lobes pointed, 3.4 to 3.6 in length, 1.2 to 1.3 times in head.

Yellowish brown in alcohol, darker above and lighter below, with a blackish spot at base of many of the scales; caudal and soft portions of dorsal and anal reddish; pectoral and ventral reddish, the former having a dark edge on uppermost ray; upper jaw dark brown and maxillary reddish.

Here described from eight specimens, 108 to 265 millimeters long, taken at Subic Bay; Calapan, Mindoro; and Bantayan Island. This is the second record of this species from the Philippines, the previous one being that of Bleeker from Manila.

The species is known from the East Indies and Japan.

Our specimens are unquestionably the above species, which is distinct from *Lethrinus haematopterus* of Richardson or *Lethrinus richardsoni* of Günther, also found in the Philippines. The latter species has all the lateral teeth in each jaw conical, whereas *L. haematopterus* Schlegel has posterior molars in each jaw, each molar provided with a distinct impression on the crown.

LETHRINUS MAHSENA (Forskål). Plate 8, fig. 1.

Sciaena mahsena FORSKÅL, Descr. Anim. (1775) 52.
Lethrinus mahsena CUVIER and VALENCIENNES, Hist. Nat. Poiss. 6 (1830); RÜPPELL, Neue Wirbelt., Fische (1840) 119, pl. 29, fig. 4; GÜNTHER, Cat. Fishes 1 (1859) 463; Fische der Südsee 1 (1873) 65, pl. 48; MEYER, Ann., Soc. España Hist. Nat. 14 (1885) 19.

Dorsal X–9; anal III–8; 46 scales on lateral line to base of caudal, 5 between lateral line and origin of dorsal, and 15 between lateral line and origin of anal; according to Günther there are 47 or 48 scales in the lateral line.

The upper profile of the markedly deep and compressed body more strongly elevated than lower, greatest depth 2.4 to 2.5 times in length; depth of head a little greater than its length which is 2.7 to 2.8 times in length of head and body together, upper profile rather steep and very slightly concave in front of eyes; the moderately and evenly convex interorbital 4 to 4.1 times in head and a little narrower than diameter of eye, which is contained 3.8 times; snout slightly elongate and pointed, 1.7 to 1.9 times in head or 2 to 2.2 times eye; maxillary extends almost to a perpendicular from posterior nostril and is contained 1.4 to 1.5 times in snout or 2.5 times in head; greatest width of preorbital 2.2 to 2.4 times in head; canines moderate, those of upper jaw markedly curved; the anterior teeth on sides

of each jaw conical, the hind ones distinct molars, some of them with a distinct longitudinal groove on crown; anterior nostril small and in a low tube, the hind one a simple, rather elongate opening, which is closer to eye than to anterior nostril; two flat bluntish spines on outer margin of opercle; caudal peduncle much compressed, its least depth 2.5 to 2.7 times in head, 6.9 to 7.4 times in length.

A patch of scales on each side of nape and another immediately behind eye above preopercle; fourth, fifth, and sixth dorsal spines highest, 2.7 to 2.8 times in length of head; last dorsal spine slightly lower than third anal spine, which is contained 2.7 to 3.2 times in head; the anal rays a little higher than long; pectoral extends to above base of anal spines and is considerably shorter than head or 3.1 to 3.2 times in length of body; ventral fin is a little shorter than pectoral, twice the length of its spine, and reaches to base of anal spines; caudal fin a little emarginate, with slightly pointed lobes, 3.2 to 3.4 times in length, 1.14 to 1.24 times in head.

The color of a fresh specimen was reddish brown with eight broad, vertical, clear yellowish green crossbands, plainest on middle and lower portions of sides and on caudal peduncle; the head was greenish brown, with two reddish bands extending forward from eyes; the dorsal and anal were reddish violet near base, clear elsewhere; the deep reddish violet caudal was broadly tipped with dark gray; the ventral and pectoral rays were reddish violet basally, grayish near the tips, the membranes transparent.

In alcohol the reddish coloration on head, sides, and fins has faded, turning to brownish violet; the lighter crossbands on trunk and caudal peduncle have remained greenish; the pectoral has become clear, with a brown spot at its base.

Here described from six specimens, 118 to 228 millimeters long, collected at Subic Bay, Tayabas Province, and Bantayan Island.

According to Günther the head is very high and somewhat gibbous between the eyes; in adults 330 millimeters long the canines are very large. Rüppell, in his admirable description of this fish, states that it is excellent food.

Günther had specimens from the Philippines and the Pelew, Fiji, and Seychelle Islands, and recorded it also from the Hervey and Paumotu Islands; Dr. A. B. Meyer collected it at Cebu. It was originally described from the Red Sea.

LETHRINUS HYPSELOPTERUS Bleeker. Plate 4, fig. 1.

Lethrinus hypselopterus BLEEKER, Ned. Tijd. Dierk. 4 (1873) 326; Atlas Ichth. 8 (1877) 144, pl. 330, fig. 3; EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 86.

Dorsal X–9; anal III–8; 46 scales on lateral line to base of caudal, 5 between lateral line and origin of dorsal, and 15 between lateral line and origin of anal.

The oblong, compressed body rather high, its depth 2.4 times in length and its upper profile more arched than the lower; head as long as deep and shorter than depth of body, 2.7 to 2.8 times in length, its upper profile before eyes concave; width of the evenly arched interorbital about twice in snout, which is contained 1.8 times in head and has a concave upper profile; diameter of the rounded eye a little shorter than width of interorbital, and 3.8 to 4 times in head; maxillary, which is 2.5 times in head, almost extends to below posterior nostril; greatest width of preorbital 2.1 times in length of head; lips thick and fleshy; four slightly curved, rather stout canines in front of each jaw, the two in the middle shorter than the outer ones; the anterior lateral teeth conical and the posterior ones large molars with distinct longitudinal depression along the middle; anterior nostril in a fleshy tube which is highest behind, and the posterior one a simple oval opening, situated halfway between anterior nostril and front rim of eye; opercle armed behind with two rather flat spines; depth of caudal peduncle contained from 2.5 to 2.6 times in length of head and 6.6 to 7.1 times in that of body.

Two patches of scales behind each eye, one above preopercle and the other just below nape; dorsal spines moderately strong, fourth to sixth highest, the last one 3.2 to 3.5 times in head; third anal spine slightly higher than last dorsal, 3 to 3.1 times in head, and the rayed anal longer than high; caudal fin slightly emarginate, with the lobes pointed; pectoral fin shorter than head, 3 to 3.2 times in length of body and extending to above anterior third of third anal; ventral spine 2.4 to 2.5 times in head and the rayed portion ends at base of anal spines.

Alcoholic specimens yellowish brown, with a deep violet-brown edge to each scale; the naked portion of head deep violet; the spinous dorsal and anal yellowish near base and blackish outwardly; rays of vertical and caudal fins blackish violet, membranous portions yellowish; ventral spine and rays washed with violet on their outward half and yellowish near base; pectoral fin whitish.

Here described from four fine specimens, 113 to 213 millimeters long, taken at Zamboanga and Davao, Mindanao; and Tambagaan and Bungau Islands, Sulu Archipelago.

This species, which is recorded for the first time in the Philippines, has, in common with *Lethrinus kallopterus,* the anal higher than long, but differs from it in having a proportionately deeper body, the vertical fins not spotted or banded, and the caudal lobes pointed.

Bleeker had specimens of this fine *Lethrinus* from Sumatra to Waigiou, off the coast of New Guinea.

LETHRINUS OPERCULARIS Cuvier and Valenciennes. Plate 9, fig. 3.

> *Lethrinus opercularis* Cuvier and Valenciennes, Hist. Nat. Poiss. 6 (1830) 214; Bleeker, Verh. Bat. Gen. 23 (1853) 14; Günther, Cat. Fishes 1 (1859) 461; Day, Fishes of India (1875) 136; Bleeker, Atlas Ichth. 8 (1877) 119, pl. 335, fig. 5.

Dorsal X–9; anal III–8; 47 scales on lateral line to base of caudal, 6 or 7 between lateral line and origin of dorsal, and 16 between lateral line and origin of anal.

The oblong compressed body moderately deep, depth 2.5 to 2.8 times in length, dorsal and ventral profiles evenly and about equally arched; head slightly longer than deep, its length slightly less than depth of body and contained 2.7 to 2.9 times in length; the convex interorbital 3.8 to 4.1 times in head and nearly as wide as eye, which is contained 3.7 to 4.3 times; snout pointed and somewhat elongate, nearly twice width of interorbital space and 1.8 to 2.3 times in length of head; maxillary extends posteriorly to or a little before vertical below front nostril, its length 2.6 to 2.9 times in head and much exceeded by greatest width of preorbital which is contained 2.2 to 2.4 times; canines of moderate size; lateral teeth of lower jaw conical in front and obtusely pointed behind; those of upper jaw conical to obtusely pointed in front and rounded behind; in front of each eye two small nostrils, the front one with a fleshy rim which is highest behind and the other a simple oval opening; opercle has two flat blunt spines at its hind margin; depth of caudal penducle contained from 7.9 to 8.5 times in length of body.

Two small patches of scales behind each eye, one above preopercle and the other just below nape; fourth, fifth, and sixth dorsal spines highest, the last one 3.4 to 3.6 times in head; third anal spine higher than second and contained 3.4 to 4 times in head; pectoral, which extends to above base of anal spines, about twice ventral spine, which is contained 2.3 to 2.5

times in length of head; ventral reaches to anus; caudal fin slightly emarginate, with the lobes pointed.

Fresh specimens light greenish brown, with pearl white spots on scales along back and on middle of sides; two bluish white lines extend forward from lower anterior margin of eye and another one from suborbital; dorsal fin colorless, irregularly barred with pinkish; anal and ventrals uniformly colorless; caudal fin crossbarred alternately with pinkish and with bluish; a reddish bar at base of the yellowish pectoral; posterior margin of opercle reddish and inside of mouth bright carmine red.

The fish is yellowish brown in alcohol, with pearl white spots on scales along back and middle of sides; anterior and posterior edges of opercle reddish; dorsal fin yellowish, with diagonal bars of blackish; caudal fin also yellow with blackish transverse bars; all the other fins yellowish; a rather obscure deep violet bar at base of pectoral.

The fourteen fine specimens in the Bureau of Science collection, forming the basis of this description, range from 100 to 255 millimeters in length and were collected in Manila Bay; Subic Bay; Calapan, Mindoro; Tacloban, Leyte; Zamboanga, Mindanao; and Jolo and Sitankai Islands, Sulu Archipelago. This species is common in the Manila market and occurs abundantly throughout the East Indies from Sumatra and Singapore to Amboina.

LETHRINUS LEUTJANUS Bleeker. Plate 4, fig. 2.

? *Lethrinus leutjanus* CUVIER and VALENCIENNES, Hist. Nat. Poiss. 6 (1830) 231.

Lethrinus leutjanus BLEEKER, Verh. Bat. Gen. 23 (1850) 14; GÜNTHER, Cat. Fishes 1 (1859) 461; Atlas Ichth. 8 (1877) 120, pl. 354, fig. 5.

Dorsal X–9; anal III–8; 46 scales on lateral line to base of caudal, 6 between lateral line and origin of dorsal, and 16 between lateral line and origin of anal.

Body oblong and compressed, dorsal and ventral profiles evenly and about equally elevated; depth 2.6 to 2.8 times in length; head longer than deep and almost as long as depth of body, its upper profile nearly straight, 2.7 to 2.9 times in length; interorbital space strongly convex and rather narrow, its width 4.1 to 4.3 times in length of head and slightly exceeding eye, which is contained 4.3 to 4.7 times in head; snout rather elongate and pointed, its length 1.8 to 2.1 times in head; maxillary, which extends posteriorly nearly to below front nostril, 1.4 to 1.5

times in snout and shorter than greatest width of preorbital which is 2.2 to 2.4 times in head; canines moderate in size and almost completely hidden in the thick fleshy lips; on each side of jaws there are conical to obtusely pointed teeth in front and molars behind, each having a distinct longitudinal impression; two small nostrils in front of each eye, the anterior having a fleshy rim which is highest behind and the other a simple oval opening situated a little more superiorly and about halfway between front nostril and anterior edge of eye; opercle armed behind with two flat blunt spines; depth of caudal peduncle 7.9 to 9.8 times in length of body or 2.9 to 3.3 times in that of head.

A patch of scales behind eye on uppermost portion of preopercle, and another one immediately above it; dorsal spines moderately high and compressed, fourth the highest and almost equal to third anal spine, which is 3.7 to 3.8 times in head; caudal fin emarginate; pectoral fin, which terminates posteriorly above base of anterior anal rays, much shorter than head and 3.3 to 3.5 times in length of body; ventral fin extends to origin of anal fin, its spine almost twice in pectoral.

The ground color in alcohol yellowish olive; head slightly olivaceous; the yellowish pectoral has a deep olive longitudinal stripe on its first two upper rays; the ventral is lightly washed with grayish posteriorly and the caudal along the middle rays; all the other fins yellowish; there is a trace of reddish color on posterior edge of opercle.

Here described from two specimens, 178 to 270 millimeters long, collected at Banaran and Sitankai Islands, Sulu Archipelago.

This species, here recorded for the first time from the Philippines, was described by Bleeker from specimens collected in Sumatra, Java, and Amboina.

LETHRINUS ORNATUS Cuvier and Valenciennes. Plate 9, fig. 1.

Lethrinus ornatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 6 (1830) 231; DAY, Fishes of India (1875) 137, pro parte; BLEEKER, Atlas Ichth. 8 (1877) 118, pl. 350, fig. 4; EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 87.

Lethrinus xanthotaenia BLEEKER, Nat. Tijd. Ned. Ind. 2 (1851) 176; GÜNTHER, Cat. Fishes 1 (1859) 461; SEALE and BEAN, Proc. U. S. Nat. Mus. 33 (1907) 244.

Dorsal X–9; anal III–8; 45 or 46 scales on lateral line to base of caudal, 6 between lateral line and origin of dorsal, and 15 between lateral line and origin of anal.

Body oblong and compressed, back strongly elevated, abdomen nearly horizontal, depth 2.3 to 2.5 times in length; length

of head equals its depth, 2.8 to 3 times in length of body and slightly less than body depth; anterior dorsal profile strongly convex, forming a broad steep curve from dorsal to the tip of the obtuse snout, which is from 1.6 to 2.1 times in length of head, and is much longer than maxillary, which reaches below posterior nostril and is from 2.5 to 2.6 times in head; the nearly flat interorbital equals the large, nearly circular eye, which is contained from 3.1 to 3.2 times in head; preorbital wider than eye and 2.3 to 3 times in head; mouth nearly horizontal; the curved canines rather small, those in upper jaw the longer, the anterior teeth on each side of upper jaw conical and pointed, and the remaining molars with a distinct longitudinal impression; the two nostrils in front of each eye rather small, the one in front with a low fleshy tube and the posterior one a simple oval opening; two flat blunt spines on posterior margin of preopercle; depth of caudal peduncle 7.6 to 8.4 times in length and 2.7 to 3 times in head.

Two patches of scales behind each eye, and ten vertical rows on opercle; the dorsal spines of moderate strength, fourth and fifth highest, the last one slightly lower than third anal spine which is contained from 2.8 to 3.2 times in head; the rayed anal about as high as long; caudal fin forked, with pointed lobes; pectoral a little shorter than head; ventral fin extends to anus, its spine 2.1 to 2.6 times in head.

Fresh specimens are greenish brown, with reddish longitudinal bands on sides; opercle edged with deep cherry red in front and behind; the dorsal fin has grayish spots along its base, its spinous portion almost colorless and narrowly margined with reddish, the rayed portion uniformly reddish; anal fin uniformly yellowish and caudal pinkish red; the pectoral has a reddish bar at base, its rays golden and the membranous portion colorless; inside of mouth bright carmine red.

In alcohol the ground color varies from greenish olive to brownish olive, with five or six reddish or yellowish longitudinal bands; the opercular membrane and the dorsal and caudal fins reddish or grayish; all the other fins golden yellow or paler, the pectoral with a blackish violet bar at base and axil; in some specimens the color of head is deeper than the body color.

The above account is based upon thirty examples, 30 to 203 millimeters long, collected at Luna, La Union; Manila Bay; Calapan, Mindoro; Halsey Harbor, Culion Island; Bantayan Island; Zamboanguita, Oriental Negros; and Malangas, Min-

danao. Evermann and Seale recorded it from Bulan, Sorsogon Province, and Seale and Bean from Zamboanga, Mindanao.

This species occurs throughout the East Indies from Sumatra to New Guinea and ranges westward to the Andaman Islands.

LETHRINUS INSULINDICUS **Bleeker. Plate 5, fig. 1.**

Lethrinus insulindicus BLEEKER, Ned. Tijd. Dierk. **4** (1873) 334; Atlas Ichth. **8** (1877) 117; **7** (1876) pl. 38, fig. 3.

? *Lethrinus mahsenoides* Ehrenberg in CUVIER and VALENCIENNES, Hist. Nat. Poiss. **6** (1830) 212.

Lethrinus mahsenoides BLEEKER, Verh. Bat. Gen. **23** (1850) 15; GÜNTHER, Cat. Fishes **1** (1859) 464; JORDAN and SEALE, Bull. Bur. Fisheries **26** (1907) 24; EVERMANN and SEALE, Bull. Bur. Fisheries **26** (1907) 87; Proc. U. S. Nat. Mus. **31** (1907) 508; SEALE and BEAN, Proc. U. S. Nat. Mus. **33** (1907) 244; JORDAN and RICHARDSON, Bull. Bur. Fisheries **27** (1908) 259.

Dorsal X–9; anal III–8; 45 scales on lateral line, 6 between lateral line and origin of dorsal, and 15 between lateral line and origin of anal.

The oblong compressed body rather deep, with the back more strongly arched than the ventral and the depth 2.3 times in length or much greater than length of head which is contained 2.9 times; head as deep as long, its upper profile much elevated and its lower profile almost straight; interorbital space is very slightly convex, its width 3.7 times in head and exceeded by length of eye, which is contained 3.3 times; snout 1.4 times in maxillary, which is 2.8 times in head; greatest width of preorbital exceeds length of maxillary and is 2.3 times in head; the canine teeth moderate in size, the lateral teeth in each jaw becoming conical and acutely pointed anteriorly and rounded posteriorly; anterior nostril has a fleshy rim which is highest posteriorly, and the other, which is a simple oval opening, is closer to eye than to anterior nostril; two flat blunt spines on posterior border of opercle; depth of caudal peduncle 7.6 times in length of body.

Behind each eye two patches of scales, one above preopercle and the other below nape; dorsal spines rather compressed and broad on one side, fourth highest and 2.9 times in head or slightly higher than second or third anal spines, which are contained 3.1 times; the rayed anal as high as long; caudal fin emarginate; pectoral fin extends posteriorly to above base of third anal spine and is almost equal to head; ventral fin terminates at origin of anal fin, its spines about twice in pectoral.

The ground color in alcohol yellowish brown; cheeks, snout, and top of head dark olive brown; the posterior part of opercle reddish; all the fins yellowish.

Here described from a single specimen, 160 millimeters long, from Zamboanga, Mindanao. Under the name of *Lethrinus mahsenoides* previous Philippine records are as follows:

Günther had a fine specimen of this species from the "Philippines," and Jordan and Seale and Evermann and Seale listed it also from the Philippines. Evermann and Seale recorded it from Jolo, Jordan and Richardson from Cuyo, and Seale and Bean from Zamboanga. Bleeker had it from the Philippines, Timor, Amboina, Celebes, and Java and, according to him, it ranges westward to the coast of Mozambique. It is very close to *Lethrinus ornatus*, from which it differs in the absence of the reddish or yellowish longitudinal bands, and in the greater depth of the body.

Genus MONOTAXIS Bennett

Monotaxis BENNETT, Life of Raffles, Fishes (1830) 688.
Sphaerodon RÜPPELL, Neue Wirbelt., Fische (1838) 112.

This genus is separated from *Lethrinus* by the scaly cheeks, and is recognized at a glance by the very large eye and the broad interorbital with a prominent lateral bulge on the very steep, boldly convex profile; the teeth in front of jaws are acute, in several rows, the external row of conical canines; a single row of molars laterally and posteriorly.

Only one species known, of very wide distribution in the Indian and Pacific Oceans. It is a very toothsome and valuable food fish.

MONOTAXIS GRANDOCULIS (Forskål). Plate 5, figs. 2 and 3.

Sciaena grandoculis FORSKÅL, Descr. Anim. (1775) 53.
Sparus grandoculis BLOCH and SCHNEIDER (1801) 276.
Chrysophrys grandoculis CUVIER and VALENCIENNES, Hist. Nat. Poiss. 6 (1830) 98.
Sphaerodon grandoculis RÜPPELL, Neue Wirbelt., Fische (1840) 113, pl. 28, fig. 2; GÜNTHER, Cat. Fishes 1 (1859) 465; Fische der Südsee 1 (1873) 67.
Monotaxis grandoculis BLEEKER, Atlas Ichth. 8 (1877) 105; 7 (1876) pl. 299, fig. 1; JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23[1] (1903) (1905) 243, fig. 101; JORDAN and SEALE, Bull. Bur. Fisheries 25 (1905) (1906) 271.
Lethrinus latidens CUVIER and VALENCIENNES, Hist. Nat. Poiss. 6 (1830) 236.

Monotaxis indica BENNETT, Life of Raffles, Fishes (1830) 683.
Pagrus heterodon BLEEKER, Nat. Tijd. Ned. Ind. 6 (1854) 54.
Sphaerodon latidens KNER, Novara, Fische (1865) 83, pl. 4, fig. 1.
Sphaerodon heterodon GÜNTHER, Cat. Fishes 1 (1859) 465; BLEEKER, Atlas Ichth. 7 (1875) pl. 299, fig. 1; MEYER, Ann., Soc. España Hist. Nat. 14 (1885) 19.

Common names.—English, big-eye; Tagalog, *malaking mata;* Visayan, *lagao* and *gapas-gapas.*

Dorsal X–10; anal III–9; 47 scales on lateral line to base of caudal, 6 between lateral line and origin of dorsal, and 15 between lateral line and origin of anal.

Depth of the oblong compressed body contained from 2.3 to 2.5 times in length, dorsal outline a little more elevated than ventral; depth of head equals its length which is 2.8 to 3.1 times in length of body; upper profile very much elevated and more or less swollen and protuberant over anterior and superior edge of orbit; interorbital space flat and contained from 2.6 to 2.8 times in head; eye large and rounded, its diameter 2.5 to 2.9 times in length of head; snout equal to or longer than eye, 2.2 to 2.6 times in head, its upper profile straight and almost vertical; maxillary, which is a little longer than snout, 2 to 2.3 times in head and extends posteriorly nearly to below center of pupil; greatest width of preorbital 1.3 to 1.6 times in length of maxillary and 2.6 to 3.4 times in that of head; mouth almost horizontal; upper jaw has six conical curved canines in front, four in lower jaw; a single series of broad molars laterally in each jaw; the two nostrils in front of each eye very small, the one in front provided with a wide flap behind and the other a simple cavity; two flat, blunt spines on posterior border of opercle; depth of caudal peduncle 7.2 to 7.8 times in legth of body.

The preopercular bones scaly, five rows of scales on each side; middle dorsal spines highest, the last one 2.5 to 2.8 times in head; third anal spine contained from 2.2 to 3.1 times in head; caudal deeply forked; pectoral, which is about as long as head, ends posteriorly above base of anterior anal rays; ventral fin extends to base of anal spines, its spine about twice in length of pectoral.

In alcohol the ground color varies from yellowish violet to brownish violet, and blackish brown, usually darker along back, the scales with violet margins; the membranous portions of dorsal, anal, and caudal dark brownish violet; ventral and pectoral yellowish, the latter fin with a violet spot at its base and

a larger one at its axil; in the young there are two white transverse bands on each side of body, descending below spinous portion of dorsal, the anterior from the first three spines and the other from the last two spines; these soon disappear and are never present in specimens of any great size. Most of the published figures are of immature specimens and give an erroneous idea of the species.

The eleven examples above described vary from 73 to 365 millimeters in length, and were collected at the following localities: Olongapo, Zambales; Ambil Island; Gaspar Island, Marinduque; Simara Island, Romblon Province; Agutaya, one of the Cuyo Islands; Samal Island, Gulf of Davao, Mindanao; and Tango and Gungao Islands, Sulu Archipelago. The only previous Philippine record is that by Meyer, who collected it at Cebu.

This fish is very abundant about rocky reefs and large quantities are at times brought to the Manila market, caught by Japanese fishermen using the muro-ami method. It is an excellent food fish, as the flesh is of a very superior quality.

It has a wide geographical range, occurring from the Red Sea eastward throughout the Indian and Pacific Oceans to Hawaii, the Society Islands, and the south coast of Australia. Wherever known it is called by a name signifying big eye.

Genus PAGRUS Cuvier

Pagrus Cuvier, Régne Anim., ed. 1 2 (1872) 272.

The oblong compressed body covered with large or moderate scales; head large, with scaly cheeks, preopercle entire; mouth low, terminal, the anterior teeth coarse and sharp, the outer series generally enlarged, caninelike, not compressed, the teeth behind the canines slender and acute; upper jaw with two rows of molars on each side, lower jaw with two or three rows of molars on each side; no teeth on vomer or palatines; posterior nostril not slitlike, much larger than anterior; dorsal rather low, spines 12, rarely 11, depressible in a groove; no antrorse dorsal spine; anal spines 3, the second one not greatly enlarged; caudal fin forked; air bladder simple; branchiostegals 6; pyloric cæca few, in one species none.

Carnivorous fishes, mostly of Europe and Africa; also occurring on the Atlantic coast of North and South America, and in East Indian and Australian waters.

Only one species is known from the Philippines.

PAGRUS SPINIFER (Forskål). Plate 8, fig. 2.

Sparus spinifer FORSKÅL, Descr. Anim. (1775) 32.

Pagrus spinifer CUVIER and VALENCIENNES, Hist. Nat. Poiss. 6 (1830) 115; GÜNTHER, Cat. Fishes 1 (1859) 472; DAY, Fishes of India (1875) 138, pl. 33, fig. 5.

Sparus spinifer BLEEKER, Atlas Ichth. 8 (1877) 109, pl. 313, fig. 3.

Pagrus longifilis CUVIER and VALENCIENNES, Hist. Nat. Poiss. 6 (1830) 118.

Dorsal XI–10; anal III–8; 54 scales on lateral line to base of caudal, 8 between lateral line and origin of dorsal, and 18 between lateral line and origin of anal.

The very deep, compressed body has the dorsal outline much more elevated than the ventral, its depth greatest at base of ventral fin and contained 1.8 times in length; head much deeper than long, its length 3.2 times in length of body, dorsal profile nearly vertical from middle of interorbital space to tip of snout and very steeply and strongly convex from origin of dorsal to interorbital; the convex interorbital has a rather prominent protuberance in front of eyes, its least width exceeding very slightly the diameter of the rounded, moderate eye which is contained 3.3 times in head; snout nearly vertical above and contained 1.7 times in head; maxillary, which is 1.4 times in length of snout, ends posteriorly below anterior margin of eye and is a little shorter than greatest width of preorbital which is twice in head; mouth horizontal and moderate in size, its jaws about equal; four conical canines in front of each jaw, and two rows of rather obtusely pointed teeth anteriorly, and of rounded molars posteriorly, on each side; the hindmost molars are rather small and appear to be arranged in three rows in lower jaw; anterior nostril a small rounded opening with a rather high fleshy flap behind, the posterior one elliptical and oblique; preopercle crenulated at its angle and lower limb; opercle has two flat bluntish points posteriorly; depth of caudal peduncle 7.3 times in total length or 2.3 times in that of head.

Scales of moderate size; six rows of scales between orbit and angle of preopercle; scales on head extend to a little behind front of eyes, leaving each side and anterior portion of interorbital space naked; snout, jaws, orbital ring, and chin naked; preopercle naked anteriorly and on its vertical and lower limbs; no scales on anterior edge of opercle; dorsal spines compressed and of moderate strength, first very short, second highest and produced into a filament which extends to base of middle dorsal rays when depressed; third, fourth, and fifth dorsal spines also

filamentous, the last 3.1 times in head; first anal spine very short and about 3 times in second, which is a little higher than third and contained 2.5 times in head; the rayed dorsal and anal similar and of nearly the same height, their last rays slightly higher than the rest; the lobes of the forked caudal pointed, the upper slightly the longer; the long pectoral is 1.4 times in head and extends to above base of posterior anal rays; ventral fin reaches origin of anal fin, its spine 1.4 times in length of head.

The fish when fresh was silvery white, with a light wash of pinkish, the middle of the longitudinal rows of scales appearing more brilliant than the ground color; the scales along back and middle of sides had bluish white spots forming longitudinal lines between the rows of scales; all the fins were pinkish, with the exception of anal, which was almost colorless; premaxillary and posterior edge of opercle were reddish; a reddish spot present above axil of pectoral.

In alcohol the upper half of body has turned silvery pink, the lower half remaining unchanged; the brilliant silvery color on scales has become golden and forms continuous bands on the middle of the longitudinal rows of scales; the bluish white lines between the rows of scales have become rather obscure; there are short, golden, longitudinal bands on the scaly portions of preopercle and opercle, narrowly edged above and below with pinkish red and alternating also with short bluish white bands; anal, pectoral, and ventrals have become very pale yellowish; dorsal and caudal fins have turned very light pinkish red; base of pectoral pinkish red as is upper jaw.

Here described from the only specimen in the Bureau of Science collection. It was purchased in a Manila public market and was caught in Manila Bay.

This fish, now recorded for the first time from the Philippines, ranges from the Red Sea and the east coast of Africa through the Indian seas to Celebes and north to the coast of southern China. It is said to reach a length of over 600 millimeters. The delicately flavored flesh is greatly esteemed.

Genus SPARUS Linnæus

Sparus LINNÆUS, Syst. Nat., ed. 10 1 (1758) 277, after Artedi.

There are four to eight conical or compressed teeth anteriorly and three or four rows of rounded molars laterally in each jaw; scales moderate, extending over the cheeks, 44 to 60 in lateral

series; body oblong, laterally compressed; dorsal fin single, with 11 to 13 spines, which fold into a scaly basal sheath; air bladder sometimes notched or with very short appendages.

A small genus, found in the warmer seas of Asia, Africa, Europe, and Australia, some individuals entering rivers.

Key to the Philippine species of Sparus.

a^1. Mouth with an outer row of rounded compressed teeth and four irregular rows on each side above, the anterior teeth small, granular; posteriorly large rounded molars .... **S. berda.**

a^2. Mouth with an outer row of rounded to obtuse molars and four rows of broad flat molars on each side .... **S. datnia.**

SPARUS BERDA Forskål. Plate 6, fig. 2.

Sparus berda FORSKÅL, Descr. Anim. (1775) 32; JORDAN and RICHARDSON, Check List Phil. Fishes (1910) 31.

Chrysophrys berda RÜPPELL, Neue Wirbelt., Fische (1840) 120, pl. 27, fig. 4; CUVIER and VALENCIENNES, Hist. Nat. Poiss. **6** (1830) 83; GÜNTHER, Cat. Fishes **1** (1859) 494; DAY, Fishes of India (1875) 140, pl. 34, fig. 2, and pl. 35, fig. 2.

Sparus hasta BLOCH and SCHNEIDER, Syst. Ichth. (1801) 275; BLEEKER, Atlas Ichth. **8** (1877) 108, pl. 345, fig. 3.

Sparus calamara RUSSELL, Fishes Corom. **1** (1803) 63, pl. 92; EVERMANN and SEALE, Bull. Bur. Fisheries **26** (1907) 86.

Chrysophrys calamara CUVIER and VALENCIENNES, Hist. Nat. Poiss. **6** (1830) 85; GÜNTHER, Cat. Fishes **1** (1859) 493.

Dorsal XI–11; anal III–8; 44 scales on lateral line to base of caudal, 4 between lateral line and origin of dorsal, and 10 between lateral line and origin of anal.

Body markedly deep and much compressed, especially along back, its greatest depth above origin of ventrals and contained 2.1 times in length, dorsal profile very strongly arched from snout to caudal, nuchal region often much elevated and appressed until it is rather sharp and ridgelike, ventral profile nearly straight from tip of lower jaw to origin of anal fin; head about as long as deep, its length less than depth of body and 2.7 to 3 times in length, its upper profile very steep and almost straight; interorbital space moderately convex, its least width 3.2 to 3.5 times, eye 3.9 to 4.9 times in head; snout, which is somewhat pointed, 2.3 to 2.8 times in length of head; maxillary is much longer than snout and reaches to below anterior edge of pupil, 2.2 to 2.5 times in head and 1.3 to 1.4 times greatest width of preorbital, the last named 3.1 to 3.3 times in head; lips broad, thick, fleshy, jaws strong and heavy, with 6 incisors in the front of each; those of upper jaw close together, forming a continuous row; in lower jaw a median interspace; behind

the canines an outer row of rounded, rather high teeth, more or less compressed; within these and covering roof of mouth are numerous teeth irregularly disposed in four rows, the anterior teeth small and granular posteriorly, becoming large molars with rounded crowns; three irregular rows of similar teeth on each side of lower jaw, within outer row, the posterior teeth of inner row much the largest; two nostrils in front of eye, the front one very small and provided with a fleshy rim and the other an elongate oblique slit which is closer to eye than to the former; opercle armed with only a single flat blunt spine at its hind border; depth of caudal peduncle 7.2 to 7.5 times in length of body.

Scales moderately large, head scaled above eyes, on preopercle, opercle, and interopercle; six rows of scales on preopercle; dorsal spines compressed on sides, the fourth highest, 2 to 2.2 times in head; third anal spine longer and much stronger than second, 1.4 to 2 times in head; caudal forked; pectoral fin, which nearly reaches to above origin of rayed anal, longer than head, 2.3 to 2.6 times in length of body; ventral fin ends posteriorly at anus, its spine 2.2 to 2.3 times in length of pectoral.

The ground color of alcoholic specimens varies from silvery gray to dark grayish, with the scales much darker at their bases; there is a deep violet spot at axil of pectoral; anal fin and posterior two-thirds of ventral blackish; dorsal fin in the largest specimen blackish, in the smaller ones edged with blackish; the naked portions of head deep violet; a blackish spot on shoulder behind opercle, which has faded in some specimens. The Malum River specimen, the only one observed alive, was very dark, blackish gray.

Here described from five examples, 141 to 277 millimeters long, coming from Paraoir, La Union; Subic Bay; Manila and Pasay, Manila Bay; and Malum River, a fresh-water stream in Tawitawi Island, Sulu Archipelago. Evermann and Seale had a specimen from Bulan, Sorsogon. The Bureau of Science collection contains two fairly large specimens from Sandakan, Borneo.

This large and excellent food fish reaches a length of more than three-fourths of a meter. It occurs from the Red Sea eastward to Celebes and the Philippines.

SPARUS DATNIA (Buchanan Hamilton). Plate 6, fig. 1.

Coius datnia BUCHANAN HAMILTON, Fishes Ganges (1822) 88, 369, pl. 9, fig. 29.

Sparus datnia BLEEKER, Atlas Ichth. 8 (1877) 109, pl. 361, fig. 4.

Chrysophrys datnia DAY, Fishes of India (1875) 140, pl. 34, fig. 1.
Chrysophrys longispinis CUVIER and VALENCIENNES, Hist. Nat. Poiss. 6 (1830) 85.
Chrysophrys hasta GÜNTHER, Cat. Fishes 1 (1859) 490, not *Sparus hasta* Bloch and Schneider; KNER, Reise Novara, Fische (1865) 88.

Dorsal X–11; anal III–8; 42 scales on lateral line to base of caudal, 4 between lateral line and origin of dorsal, and 10 between lateral line and origin of anal.

Dorsal profile more strongly arched anteriorly and ventral outline nearly straight from lower jaw to anal fin; depth of the oblong compressed body 2.4 times in length; head as long as deep, much shorter than depth of body and 3 times in length; interorbital space markedly convex, its least width 3.2 times eye, 3.8 times in head; the short, rather rounded snout 2.7 times in head and a little shorter than maxillary which is contained 2.5 times and extends posteriorly to below anterior edge of pupil; greatest width of preorbital equal to least width of interorbital space; six incisors in front of each jaw; the lateral series of teeth in upper jaw consists of an outer row of rounded to obtuse molars, and within this four rows of broad flat molars on each side; lower jaw with four rows of molars on each side, those of outer row almost all rounded; anterior nostril very small and provided with a narrow fleshy rim; the posterior one is a simple, rather elongate slit obliquely in front of eye; depth of caudal peduncle 8.1 times in length of body.

Head naked behind eye and on interorbital space, snout, orbital ring, upper and lower jaws, chin, and outer edges of preopercle; dorsal spines compressed, broader on one side, fourth highest and contained 1.3 times in second anal spine, which is higher than third and 3.3 times in head; pectoral fin extends to above base of anal spines, and is more than twice ventral spine, which is 1.9 times in head; the rayed portion of ventral reaches to origin of anal fin; caudal fin emarginate.

The ground color in alcohol is silvery olive, the scales darkest at their bases; dorsal and outer two-thirds of ventrals blackish; ventral also blackish excepting its outer margin which is whitish; caudal fin blackish near base and at its outer portion; pectoral is yellowish and has a blackish spot superiorly at its axil.

Here described from a single specimen, 174 millimeters long, collected at Paraoir, La Union. There are several examples from Amoy and Hongkong in the Bureau of Science collection. Kner had a specimen from Manila.

This species is found from the Red Sea throughout the seas of India and the East Indies to Celebes and the Philippines. It grows to a length of nearly 500 millimeters.

KYPHOSIDÆ

RUDDER FISHES

This small group, sometimes divided into two families, includes a few species of herbivorous fishes. They occur chiefly in the warmer parts of the Pacific Ocean, the West Indies, and the Mediterranean Sea, where they occur about reefs, feeding principally, if not entirely, on marine algæ. They are all eaten, and some are much prized for food. They occur in schools, sporting in the current about submerged rocks and coral masses in the interstices of which they feed, much as a flock of sheep gambols on the green.

The oblong or somewhat elevated body is covered with moderate-sized or small scales, ctenoid or cycloid. The small mouth is without molars, the anterior teeth resembling incisors; teeth may be present or absent on the vomer and palatines; the premaxillaries are protractile; the narrow preorbital forms a sheath for the maxillary; the dorsal fin is continuous, with 10 to 15 rather strong spines, the soft dorsal naked or scaly; anal with 3 spines; ventral thoracic, I-5, an accessory scale at the base; the caudal lunate or forked; all the pectoral rays branched. Opercles entire; gills 4, a slit behind the fourth; gill membranes separate, free from the isthmus; gill rakers moderate; pseudobranchiæ well developed; air bladder usually with two posterior horns; vertebræ 24 to 28; post-temporal of ordinary percoid form, the stout forks not adnate to the cranium.

Key to the Philippine genera of Kyphosidæ.

a^1. Soft part of dorsal and anal naked, dorsal base partly covered with scales; teeth all movable, incisors all tricuspid........................ **Girella.**

a^2. Soft parts of vertical fins closely scaled; teeth not freely movable; fine teeth on vomer, palatine bones, and tongue............................ **Kyphosus.**

Genus GIRELLA Gray

Girella GRAY, Ill. Ind. Zool. 2 (1833) 98.

The laterally compressed, oblong-ovate body covered with rather large scales; scales on cheeks very small, opercles and top of head chiefly naked; mouth small, with a series of tricuspid, movable incisors, behind which is a broad band of similar, smaller

ones; no molars, and no teeth on tongue or vomer; the lower pharyngeal teeth slender.

Dorsal fin tolerably low, with 14 or 15 spines, its base partly covered with scales which form an imperfect sheath; anal spines small, graduated; caudal lunate; gill rakers slender; pyloric cæca numerous, the intestinal canal elongate; the air bladder divided posteriorly into two horns; peritoneum black; vertebræ 11 + 16 or 17 = 27 or 28.

This is a genus of herbivorous fishes, feeding on seaweeds, and confined to the Pacific Ocean. Several species are known from the coasts of Japan, China, Formosa, and Australia, and one is known from the rocky coast of California.

GIRELLA PUNCTATA Gray. Plate 7, fig. 1.

> *Girella punctata* GRAY, Ill. Ind. Zool. 1 (1830) pl. 98, figs. 3 and 4; GÜNTHER, Cat. Fishes 1 (1859) 427, pro parte; STEINDACHNER and DÖDERLEIN, Denkschr. K. K. Akad. Wiss. Wien 47 (1883) 231; JORDAN and STARKS, Proc. U. S. Nat. Mus. 32 (1907) 497, fig. 5; JORDAN and THOMPSON, Proc. U. S. Nat. Mus. 41 (1912) 589, fig. 12.
>
> *Crenidens punctatus* RICHARDSON, Ichth., China, Rept. Brit. Assoc. Ad. Sci. (1845) 242.

Dorsal XV–13; anal III–12; 56 scales on lateral line to base of caudal, 10 between lateral line and origin of dorsal, and 18 between lateral line and origin of anal.

The oblong-ovate body compressed, with profiles evenly and about equally arched; greatest depth at about middle of ventral and contained 2.4 times in length; head slightly longer than deep, its length 3.1 to 3.2 times in length of body; width of the convex interorbital 3.2 to 3.3 times in head and equal to diameter of the almost circular eye; the slightly rounded snout 2.8 to 3.1 times in head and a little longer than maxillary, which is contained 3 to 3.2 times in head and extends to below anterior rim of eye; preorbital 3.8 to 4.2 times in head at its greatest width; mouth small, with strongly oblique gape and equal jaws; in front of each jaw is a single row of tricuspid incisorlike teeth, behind which is a band of much smaller ones; two small rounded nostrils in front of each eye, the front one with a rather fleshy flap behind and the other a simple opening; preopercle minutely serrated on its hind limb and only posteriorly on its lower limb; opercle has a rather sharp spine at its posterior edge.

Scales roughly ctenoid and rather small; snout, jaws, orbital ring, subopercle, lower half of opercle, and anterior portion of interorbital space naked, rest of head scaled; dorsal spines in-

crease in height toward the last, which is 2.1 to 2.6 times in head; dorsal rays slightly higher; third anal spine highest, 2.2 to 2.8 times in head and much lower than anal rays; caudal fin slightly emarginate; the rounded pectoral is 1.2 to 1.4 times in head and does not reach to vertical from anus; ventral fin almost reaches anus, its spine 1.4 to 1.5 times in head.

The ground color uniformly brown, slightly lighter along ventral edge of body and head; vertical fins and ventral almost as dark as body, caudal and pectoral lighter colored; a narrow brownish bar at base of pectoral.

This species is here described from three specimens, 46 to 66 millimeters long, taken at Dodd Island, Amoy, and Hongkong. So far as is known, it is found along the coasts of China and southern Japan. In all probability it also occurs in Philippine waters and is to be expected in the Batan Islands.

Genus KYPHOSUS Lacépède

Kyphosus LACÉPÈDE, Hist. Nat. Poiss. 3 (1802) 114.
Pimelepterus LACÉPÈDE, Hist. Nat. Poiss. 4 (1803) 429.

The moderately appressed body elongate-ovate, with short head, blunt snout, and large eye; mouth small, horizontal, maxillary barely reaching a perpendicular from front of eye; in both jaws outer row of teeth of rather narrow, obtusely lanceolate incisors, implanted with conspicuous compressed horizontal processes or roots posteriorly; behind these a narrow band of villiform teeth; fine teeth on vomer, palatine bones, and tongue; preopercle generally denticulate; the narrow preorbital covers but little of maxillary; entire body covered with thick, medium-sized or smallish scales, which also cover most of head; 50 to 70 scales in lateral line; the soft parts of vertical fins thickly covered by small to minute scales, which also extend upon caudal and paired fins; dorsal fin low, with 11 spines, which are depressible in a groove of scales, the fin continuous but the last spines low so that a depression occurs between the spinous and soft portions; soft dorsal low or elevated anteriorly, pointed behind; anal like soft dorsal, with 3 spines; caudal fin moderately forked; pectorals small, ventrals well behind them; branchiostegals 7; gill rakers long; pyloric cæca usually very numerous, intestinal canal long; air bladder notched posteriorly and sometimes anteriorly; vertebræ 9 or 10 + 15 or 16 = 25.

A small genus of herbivorous fishes, found in tropical waters and ranging northward occasionally to Japan and New England.

Key to the Philippine species of Kyphosus.

a^1. Dorsal rays 12, highest anteriorly, much higher than spinous part; base of dorsal rays shorter than spinous base................ **K. cinerascens.**
a^2. Dorsal rays 14, uniform in height, lower than spinous part.... **K. lembus.**

KYPHOSUS CINERASCENS (Forskål). Plate 7, fig. 3.

Sciaena cinerascens FORSKÅL, Descr. Anim. (1775) 53.
Pimelepterus cinerascens DAY, Fishes of India (1875) 143, pl. 35, fig. 3; BLEEKER, Atlas Ichth. 9 (1877) 15, pl. 364, fig. 4.
Kyphosus cinerascens JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1907) (1908) 260; WEBER, Siboga Exp., Fische (1913) 194.
Pimelepterus indicus Kuhl and Van Hasselt in CUVIER and VALENCIENNES, Hist. Nat. Poiss. 7 (1831) 201.
Pimelepterus altipinnis CUVIER and VALENCIENNES, Hist. Nat. Poiss. 7 (1831) 201.
Pimelepterus dussumieri CUVIER and VALENCIENNES, Hist. Nat. Poiss. 7 (1831) 203; CUVIER, Régne Anim., Poiss., Disciples Ed. (1836) pl. 43, fig. 1.
Pimelepterus tahmel RÜPPELL, Neue Wirbelt., Fische (1840) 35, pl. 10, fig. 4; GÜNTHER, Cat. Fishes 1 (1859) 499.

Dorsal XI–12; anal III–11; 53 scales on lateral line to base of caudal, 10 between lateral line and origin of dorsal, and 18 between lateral line and origin of anal.

The elongate-ovate body moderately compressed, evenly arched above and below, its greatest depth 2.2 to 2.3 times in length; length of the short head a little longer than its depth and contained 3.4 to 3.7 times in length of body; upper profile more strongly elevated than ventral; the convex interorbital has a swelling in front of eyes, its least width 2.4 to 2.6 times in head and slightly exceeding the length of the blunt, rounded snout which is contained 2.7 to 2.8 times; diameter of the large rounded eye 3.2 to 3.5 times in head and slightly shorter than maxillary which is contained 3.1 to 3.3 times and extends to below anterior rim or orbit; widest portion of preorbital 3.4 to 3.9 times in length of head; mouth rather small, its gape horizontal; the compressed incisors in a single row in each jaw, their horizontal portions longer than the vertical; a narrow band of villiform teeth behind incisors, and minute teeth on vomer, tongue, and palatines; the two small nostrils overhung by the prefrontals have a low fleshy rim; preopercle minutely serrated behind and below, the serration more noticeable at the angle; a flat, blunt spine at hind edge of opercle and an indication of a smaller one above it; caudal peduncle compressed, its least depth 7 to 7.6 times in length of body and 2 to 2.1 times in that of head.

Scales moderate in size, those thickly covering head and fins very small to minute; head naked on snout and jaws, and scaled on the remaining portions; dorsal spines increase in height to sixth or seventh, which is 2.4 to 2.6 times in head and much lower than anterior dorsal rays which are much the highest of the soft portion; base of dorsal rays shorter than that of spinous portion; third anal spine highest; soft anal equal to or a little higher than soft dorsal, contained 1.5 to 1.7 times in head, its outline much like that of dorsal; base of rayed dorsal longer than that of soft anal but shorter than head; caudal emarginate with pointed lobes; the short pectoral a trifle longer than ventral, which is 1.8 to 1.9 times its spine and 1.5 times in length of head.

Color in alcohol varies from silvery gray to blackish, with silvery or whitish centers to the scales, forming longitudinal bands which alternate with dark bands between the longitudinal rows of scales; the fins are darker than the ground color; the dark longitudinal bands on the sides were bright golden in life.

Of this species the Bureau of Science collection has eleven specimens, described above. They range from 32 to 320 millimeters long and were collected at the following localities: Iba and Subic Bay, Zambales; Tanao and Taylon Islands, Camarines Norte; Dumaguete, Oriental Negros; and Tubigan and Bungau Islands, Sulu Archipelago. A fine specimen from the Philippine Islands was recorded by Günther as *Kyphosus tahmel*, and another from Calayan Island of the Babuyan group by Jordan and Richardson.

The species occurs from Sumatra to New Guinea, and northward to southern Japan.

KYPHOSUS LEMBUS (Cuvier and Valenciennes). Plate 7, fig. 2.

Pimelepterus lembus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 7 (1831) 201; GÜNTHER, Cat. Fishes 1 (1859) 498; BLEEKER, Atlas Ichth. 9 (1877) 15, pl. 364, fig. 1.

Pimelepterus ternatensis BLEEKER, Nat. Tijd. Ned. Ind. 4 (1853) 605; GÜNTHER, Cat. Fishes 1 (1859) 499.

Samal name, *ilak*.

Dorsal XI–14; anal III–12 or 13; 53 to 55 scales on lateral line to base of caudal, 11 or 12 between lateral line and origin of dorsal, and 18 or 19 between lateral line and origin of anal.

The elongate-ovate body moderately compressed, with the profiles evenly and equally arched, its greatest depth at middle and contained 2.2 to 2.5 times in length; the short head a trifle

longer than deep, its profiles convex and its length 3.3 to 3.9 times in length of body; interorbital space convex and rather prominent in front of eyes, its least width 2.2 to 2.8 times in length of head and greater than the length of the blunt, rounded snout which is contained 2.7 to 3.3 times; eye rounded and moderate in size, its diameter 3.4 to 4 times in head; maxillary, which barely reaches vertical from front margin of eye, slightly longer than greatest width of the smooth preorbital which is contained 3.3 to 3.9 times in length of head; mouth horizontal and rather small, each jaw with a series of rather narrow compressed, folded or bent incisors, their horizontal posterior part longer than vertical portion; behind them a narrow band of villiform teeth; minute teeth on vomer, tongue, and palatines; the two small nostrils in front of each eye each provided with a fleshy rim; preopercle minutely serrated on its lower and hind edges, and opercle armed behind with a flat, blunt spine; depth of caudal peduncle 8.1 to 9.4 times in length of body or 2.4 to 2.5 times in that of head.

Sides of body covered with moderate scales; snout and jaws naked, as are the membranous portions of dorsal and anal; the soft vertical fins, caudal, ventrals, and pectoral have a thick cover of very small to minute scales; the lateral line skips several scales on anterior portion of body; sixth or seventh dorsal spine highest, 2.3 to 2.6 times in head and perceptibly higher than soft portion which is nearly uniform in height throughout and longer than head; rayed anal much higher than third anal spine or soft dorsal, and contained 2.1 to 2.5 times in head, its base a little shorter than head; caudal fin forked, with acutely pointed lobes; the short pectoral 1.4 to 1.7 times in head; ventral still shorter than pectoral and 1.6 to 2 times its spine, which is 2.8 to 3.2 times in head.

Color in alcohol uniformly silvery gray, much darker above; the sides have longitudinal dark bands passing between the rows of scales, alternating with silvery bands running through their centers; the fins blackish; the dark longitudinal bands were golden in life.

We have examined twelve specimens of this species in the Bureau of Science collection, measuring 34.5 to 330 millimeters in length. They were obtained at the following localities: Iba, Zambales; Calapan, Mindoro; Tablas Island; Iloilo, Panay; Dumaguete, Oriental Negros; Zamboanga, Mindanao; and Siasi and Sibutu Islands, Sulu Archipelago.

The fish of this species go in small or moderately large schools and delight to play and feed in strong currents on coral reefs rising abruptly out of considerable depths. Such places as the dock at Sibutu, where the overhanging reef drops off to a depth of 85 or 90 fathoms, are excellent places from which to observe them.

This handsome fish occurs from the western coast of the Malay Peninsula to Amboina and other islands of the Moluccas.

SUMMARY OF PHILIPPINE SPAROID AND RUDDER FISHES DESCRIBED IN THIS PAPER

1. SPARIDÆ

1. Genus LETHRINUS Cuvier

1. **moensi** (Bleeker).
2. **nematacanthus** Bleeker.
3. **miniatus** (Forster, MS.).
4. **amboinensis** Bleeker.
5. **richardsoni** Günther.
6. **cutambi** Seale.
7. **kallopterus** Bleeker.
8. **variegatus** Ehrenberg.
9. **ramak** (Forskål).
10. **atkinsoni** Seale.
11. **harak** (Forskål).
12. **haematopterus** Schlegel.
13. **mahsena** (Forskål).
14. **hypselopterus** Bleeker.
15. **opercularis** Cuvier and Valenciennes.
16. **leutjanus** Bleeker.
17. **ornatus** Cuvier and Valenciennes.
18. **insulindicus** Bleeker.

2. Genus MONOTAXIS Bennett

19. **grandoculis** (Forskål).

3. Genus PAGRUS Cuvier

20. **spinifer** (Forskål).

4. Genus SPARUS Linnæus

21. **berda** Forskål.
22. **datnia** (Buchanan Hamilton).

2. KYPHOSIDÆ

5. Genus GIRELLA Gray

23. **punctata** Gray.

6. Genus KYPHOSUS Lacépède

24. **cinerascens** (Forskål).
25. **lembus** (Cuvier and Valencinnes).

ILLUSTRATIONS

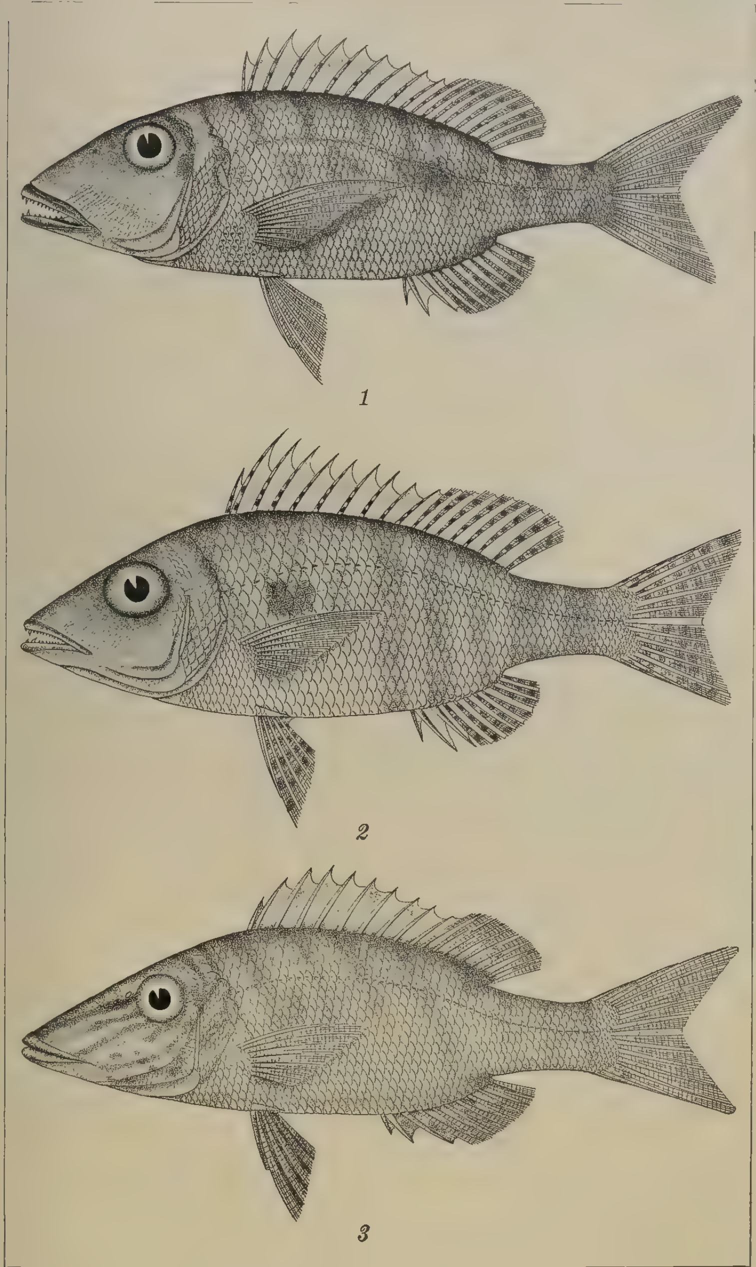

PLATE 1.

1

2

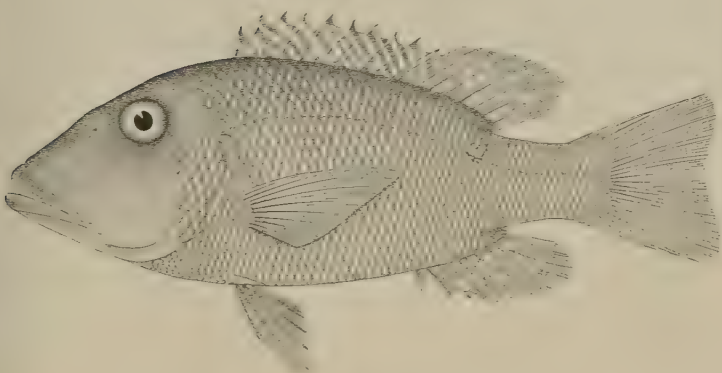

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PLATE 2.

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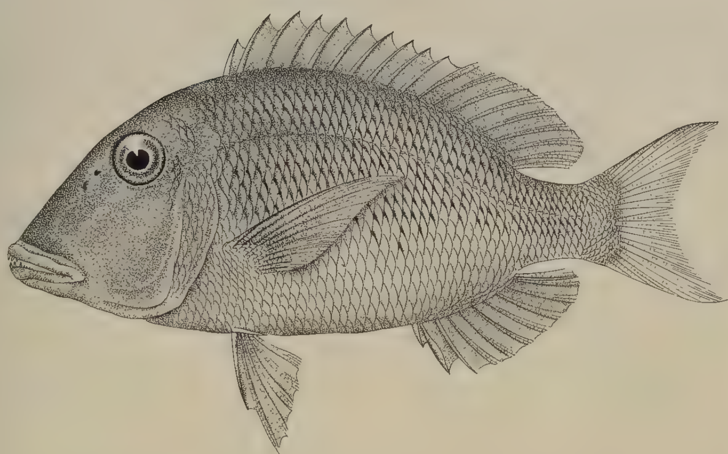

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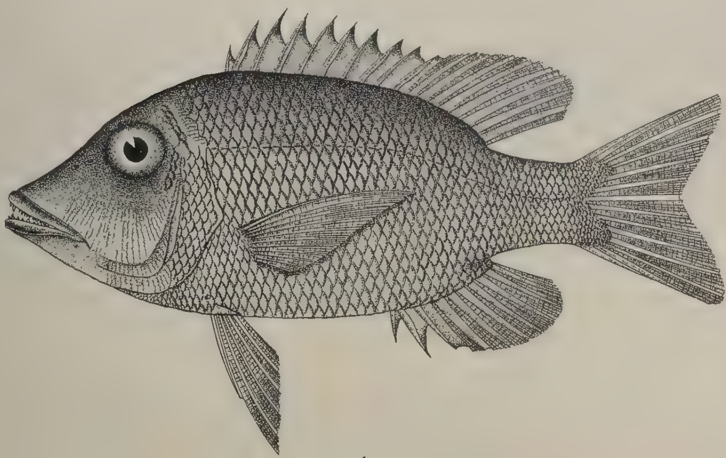

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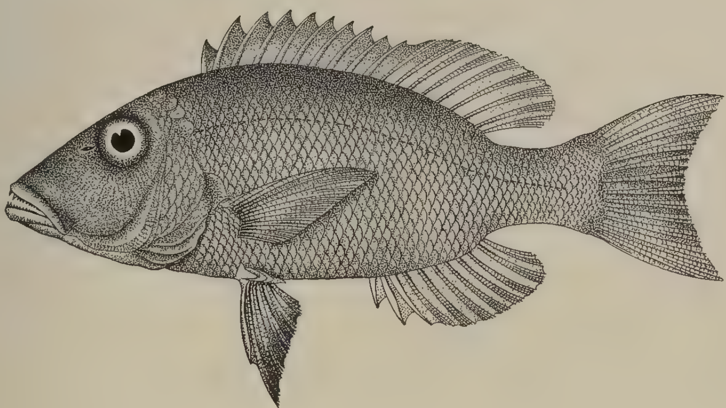

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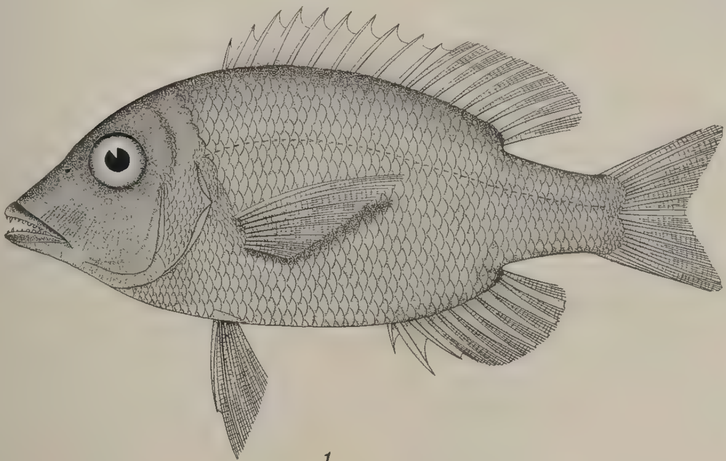

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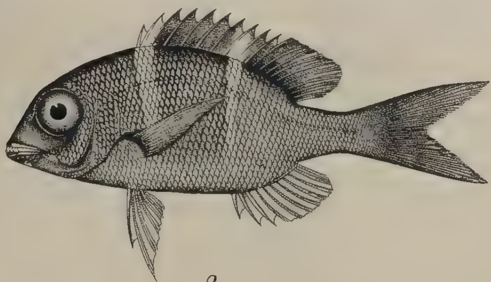

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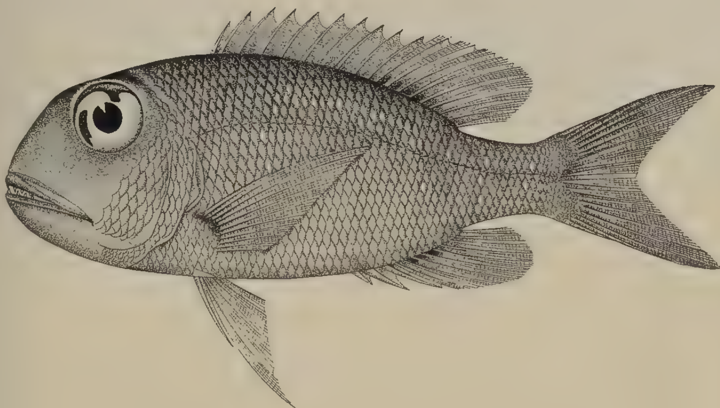

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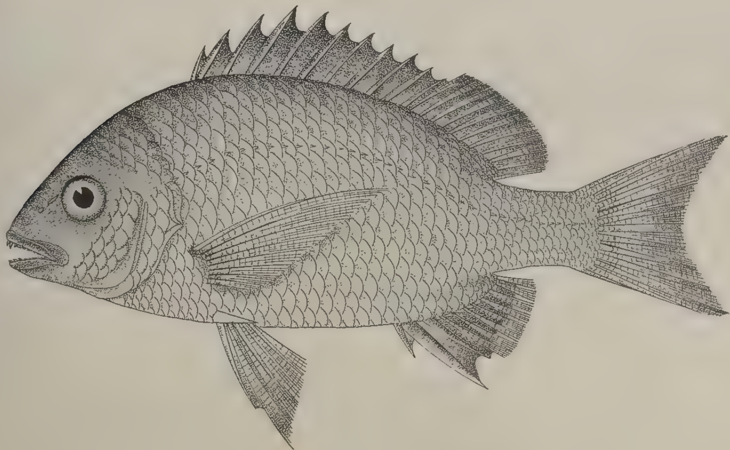

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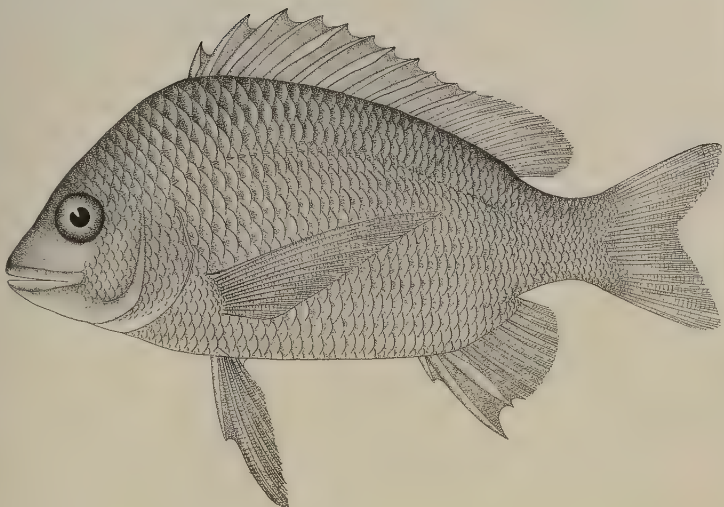

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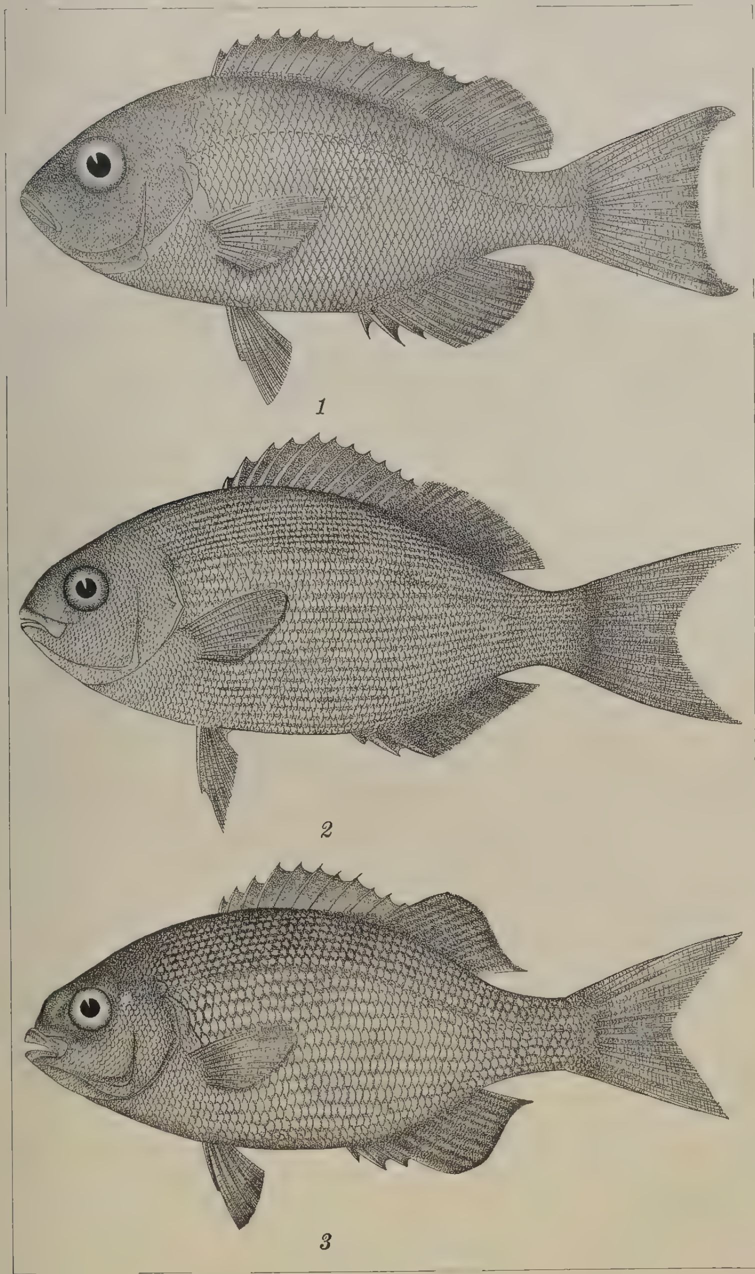

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PLATE 7.

1

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PLATE 8.

1

2

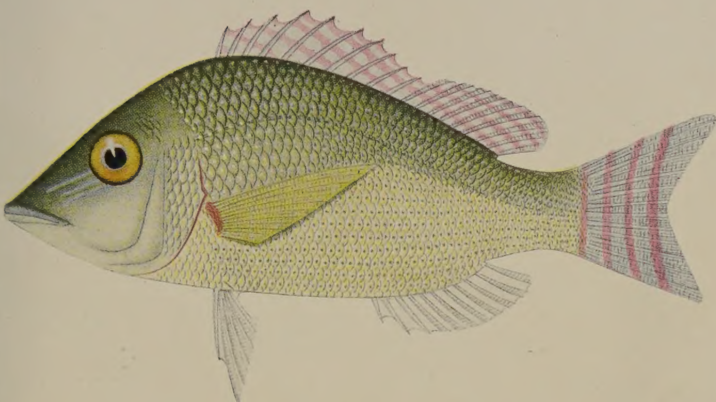

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PLATE 9.

ERRATA

VOLUME 29

Page 549, between lines 13 and 14 insert **Lomanius minimus sp. nov.**

VOLUME 31

Page 466, line 27, *for* correctly exserted *read* porrectly exserted.